CRM Recovery Replication Activity Report – LIFE EU/UK/000344

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Executive Summary

The main objective of the Critical Raw Materials Closed Loop Recovery project (CRM Recovery) was to investigate if changes to the way WEEE is collected could result in the economic recovery of CRMs through re-use and the development of innovative recovery methods. Specifically, the project aimed to demonstrate collection and recovery methods, which if scaled-up, could increase the recovery of target CRMs from WEEE by 5% by 2020 and 20% by 2030.

This report sets out the actions taken by the project to achieve these aims and objectives. Specifically, this document reports on the outcomes of the project's trials and their potential for replication, as well services that are currently being undertaken which have replicated trial activities and/or have been set up as a direct result of the project. In addition, the report provides recommendations for additional replication activities required to increase the recovery of CRMs from WEEE and demonstrates how the scaling up of activities undertaken during the project trials would achieve the project targets to increase CRM recovery.

This report highlights that whilst the recovery trials (and in particular bio-leaching), proved effective at increasing the recovery of CRMs from WEEE, to achieve the economies of scale necessary for commercial viability, separate collections of CRM-rich WEEE is necessary. However, significant investment is necessary to further develop the recovery methods tested, to increase their technology readiness levels (TRL), and develop these methods to demonstration stage. Further investment will be needed to achieve commercial readiness.

The project proved that currently, the most effective way to recover CRMs is through re-use operations. However, whilst technically proven, many re-use activities are loss-making, and operate in a fragmented market dependent on charitable organisations, social enterprises, and less frequently commercial enterprises, for their continued delivery. The CRM Recovery project demonstrated that, through the use of collaborative business models involving charities and private sector retailers, re-use models could increase their profitability. Furthermore, the project demonstrated the importance of high-quality collections which require both the separation of CRM-rich WEEE and limited damage during the transportation phase.

Findings from the project highlighted the importance of raising consumer awareness to increase WEEE collections and their financial viability, and reduce product hoarding. Therefore, in order to increase the recovery of CRMs through the scaling up of re-use models, it may be necessary to invest in high profile consumer engagement campaigns, as well as behaviour change interventions, to encourage consumers to both correctly dispose of WEEE and to separate CRM rich products.

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Contents

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List of Tables and Figures

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Acronyms

CRM	Critical Raw Materials
EEE	Electrical and Electronic Equipment
EPR	Extended Producer Responsibility
EU	European Union
ICT	Information Communications Technology
LDAs	Large Domestic Appliances
PCBs	Printed Circuit Boards
PGMs	Platinum Group Metals
PPM	Parts per Million
REEs	Rare Earth Elements
SG	Specific Gravity - the weight of a volume of fluid or solution as compared to the weight of the same volume of water
SDAs	Small Domestic Appliances
WEEE	Waste Electrical and Electronic Equipment
WG	Waste Generated

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1. Introduction

Across Europe a significant amount of waste electrical and electronic equipment, otherwise known as WEEE, is thrown away, often ending up in landfill. In turn, critical raw materials, or CRMs, that are present within these unwanted products - such as gold, silver, platinum group metals and rare Earth elements - are also wasted. This represents an unnecessarily high cost to the economy. To demonstrate the scale of the problem, in the UK alone we landfill over 500,000 tonnes of WEEE every year, which includes a tonne of valuable gold.

In 2015, approximately 9.8 million tonnes of EEE was placed on the market in Europe, by 2016 this increased to 10.1 million tonnes. If all EEE placed on the market was subsequently disposed, Eurostat reports show that only around one third of WEEE generated is effectively managed by being collected and recycled. This WEEE in turn has a CRM recovery rate of a mere 1%, these figures made it clear that action needed to be taken.

The Critical Raw Material Closed Loop Recovery Project (CRM Recovery) was set up to address this problem. Led by WRAP, in partnership with EARN, ERP UK, KTN and the Wuppertal Institute, the team set out to demonstrate innovative methods, which if scaled-up, could increase the recovery of target CRMs from WEEE by 5% by 2020 and 20% by 2030, with the latter being worth €381m in gold, silver and platinum alone.

The project tested methods to collect, aggregate and recover CRMs, through a series of WEEE collection and recovery trials which took place in the UK, Italy, Germany and the Czech Republic, in order to evaluate the technical, economic and environmental viability as well as the societal benefits of the methods trialled. These trials were a key element of project activities (outlined below) and were instrumental to the achievement of project targets.

Table 1.1 Project Activities

CRM Recovery Project Activities	
Stage 1 - Collection Trials:	Collection routes/mechanisms for WEEE re-use, repair and recovery were trialled, including incentivised takeback, collection events and novel approaches to collection methods and facilities, with the aim of aggregating CRM rich products.
Stage 2 - Recovery Trials:	Items from the collection trials suitable for re-use were separated from those suitable only for recovery. The latter were disassembled to segregate CRM rich target components for reprocessing or component re-use. Recovery trials were conducted to establish the technical and economic impact of sorting, separation and materials concentration activities on recovery processes.

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Stage 3 - Trial and Project Evaluation:	Data gathered was used to assess the environmental and economic potential of the collection and recovery processes to increase CRM recovery, as well as the socio-economic benefits.
Stage 4 - Policy and Infrastructure Recommendations:	Using the trial data and evaluation, EU-wide policy and infrastructure recommendations were presented, which are also relevant at national and regional levels.

Core to the achievement of the project aims to demonstrate opportunities to increase recovery of CRMs, is the identification of replication activities and opportunities to scale-up activities undertaken during the project trials, which will contribute either directly or indirectly to these ambitious targets.

Furthermore, replication of practices which increase the capture and recovery of CRMs across the EU is vital to reducing supply chain risk and volatility, the environmental impact of CRM production, and to address the economic value lost through current collection and recovery systems.

This report provides an assessment of the replication activities necessary to achieve the project aims, highlights achievements resulting directly from the CRM Recovery project, and further supporting actions necessary to achieve the project's desired outcomes. Specifically, this report discusses three key areas of replication:

1. consumer engagement and knowledge transfer;
2. infrastructure development including Research Development and Innovation (RD & I); and
3. policy instruments in the context of each, the project, on-going replication activities and further actions necessary, and where possible assessments of their (potential) benefit.

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2. Engagement and Knowledge Transfer

2.1. Context

Increasing effective consumer engagement is vital to ensuring that valuable CRMs are recovered through collection of WEEE from households and enable product re-use. In 2015, approximately 9.8 million tonnes of EEE was placed on the market in Europe, by 2016 this increased to 10.1 million tonnes. If all the EEE placed on the market was subsequently disposed, Eurostat reports show that only around one third of WEEE Many modern electrical and electronic products contain several of the materials classified as CRMs by the European Commission, and are at risk of not being captured if WEEE is not re-used or recycled. **More than 10 million tonnes of WEEE is generated in the EU every year and the amount captured for recycling is only around 45%.** Despite this, there has been little research on consumer values and motivations which could be targeted through effective consumer behaviour change initiatives to increase the collection of WEEE. Whist many organisations conduct awareness raising activities, the delivery of targeted behaviour change campaigns to improve WEEE collections are limited.

In the context of this report, 'consumer engagement' relates to communications aimed at both business and householders as consumers of EEE and producers of CRM rich WEEE. 'Business engagement and knowledge transfer' activities relate specifically to the sharing of information, knowledge and insight across the WEEE collections, re-use and recovery value chain. Within the CRM Closed Loop Recovery project, both types of engagement activities were undertaken, and moreover, are considered instrumental to ensure replication and scaling up of the project activities.

2.2. Consumer Engagement Activities

Together, the five trial hosts undertook 14 different collections activities which each involved engagement activities to promote WEEE recycling and re-use and engaged a wide range of consumers including children, parents, teachers, householders and individuals at their place of work.

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Figure 2.1 Communications Materials from UK and Italian Collection Trials

Central to the delivery of each of the CRM project collections trials was the development and use of communications materials to promote consumer participation in each trial (see Figure 2.1 above). Visually engaging communications materials were utilised to engage consumers and encourage use of the trials collection schemes.

In addition, surveys were undertaken with consumers in the catchment area for each trial to understand their habits in relation to WEEE their awareness of local channels to re-use or recycle WEEE, actions which could encourage greater collection of WEEE, and changes in attitudes and behaviours associated with participation in a CRM project trial. These activities consistently identified the following challenges and barriers to consumer engagement, which should be addressed in replication activities to encourage scaling up of the trial's outcomes:

- **Knowledge of what to do is important** – Having more information available about where to take WEEE encourages re-use and recycling
- **Disposal needs to be convenient** - Using high street and charity retailers was considered a very **convenient** way to dispose of WEEE.
- **Pro-environmental messaging helps to encourage re-use and recycling** - most respondents agreed that disposing of their WEEE through takeback schemes was good for the environment.

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- **Trust plays an important part in increasing WEEE collections** – consumers reportedly place more trust in high street retailer brands than charities to handle their data securely.
- **Personal connection matters and increases the economic viability of collections** - there is a link between the collection of high quality/high value products and human interaction at collections points. People are more likely to donate better quality items if they can drop them at a collection point where they have personal interaction with an operative which helps to build trust in the service, makes it more enjoyable for consumers, and encourages people to recycle if their efforts to do the right thing are recognised.

It has not been possible to accurately determine the number of individuals that participated in the collection trials or that may have been exposed to and potentially influenced (either directly or indirectly e.g. via 'pester power') by the trials and associated communications. The surveys also did not gather information about the extent to which consumer behaviour have changed over the longer term. However, the figures reported through the CRM project indicators (as shown in Table 2.2 below) have been derived from verifiable evidence and report the number of individuals which responded to trial surveys and were engaged via project level dissemination activities.

Table 2.2: Project Level Engagement Indictors – Consumer Engagement

Indicator	Descriptor	Units and targeted impact	End of Project: as at 22/03/2019
Other tools for reaching/raising awareness of the general public	Use of social networking sites, presentations, case studies and publication of project results. Measured by followers on social networking sites	200 individuals	574 followers on social media and 273 members on LinkedIn
Surveys carried out regarding awareness of the environmental/climate problem addressed (only obligatory for information and awareness projects)	1,100 sample size individual survey; smaller number of depth interviews with stakeholders	No. of individuals covered/survey	2,542 Surveys and interviews conducted 3 surveys have been designed: 1. Economic interview 2. Pre-trial socio-economic survey 3. Post-trial socio-economic survey

2.3. Business Engagement and Knowledge Transfer Activities

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Whilst there are many resources and networks available which those within the WEEE value chain can use to access information on both a national and international level (**https://orama-h2020.eu/downloads/#tab-id-2**), the Critical Raw Materials Recovery project was one of the first projects of its kind to develop and deliver demonstration pilots that engaged and worked across the value chain to increase the recovery of CRMs. Indeed, the design of the collection and recovery trials was facilitated through consultation with the supply chain, undertaken prior to the procurement and trial host selection. Together the five trial hosts worked with over 25 organisations to successfully execute 14 collection and 7 recovery activities. These trials demonstrated the value of collaborative ways of working and knowledge sharing, not commonplace today. Furthermore, and core to the management of the project and delivery of key project outputs, knowledge transfer and collaborative working were promoted through the Stakeholder Group, the supply chain consultation element of the B3 and B4 deliverables (Policy and Infrastructure Recommendations reports) and broader project dissemination and networking activities.

All project activity delivered under the D1 (Communications and Dissemination) work package will, in some respect, encourage the replication and advancement of the CRM Recovery project aims and objectives:

- The project **newsletters** have provided project and topic-specific updates.
- The project **case studies** contain information around learnings and processes that others can review and adopt.
- The project's **conferences** have allowed people to discuss topic-related issues, connect with each other and potentially stimulate future collaboration. We will be undertaking some activity at the Final Conference to enable like-minded organisations connect both on the day, and post-event (the KTN will be managing and facilitate introductions via a tailored delegate list).
- The projects **layman's report** is written in a succinct and visual way so that the outputs, processes and policy messages are understandable to as many people as possible.
- The message around **policy recommendations** has been pushed out via social media, within the project's flagship Final Conference and disseminated via a 'Policy Webinar' supported by the WEEE Forum.
- A **policy infographic** was produced with simple messages on how to improve collection and recovery.
- The project launched a **podcast** as part of the Ellen MacArthur Foundation's Disruptive Innovation Festival 2018, pushing out the message to a wider and more varied audience.

As with the consumer engagement activities, it has not been possible within the scope of this project to evaluate the full reach of these activities or the extent to which they have directly influenced replication activities. However, Table 2.3 (below) provides detail of verifiable activities and reported progress against relevant project indicators.

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Table 2.3: Project Level Engagement Indictors – Value Chain Knowledge Transfer

Indicator	Descriptor	Units and targeted impact	End of Project: as at 22/03/2019
Stakeholder Group membership	Number of Individuals Representing the Supply Chain and Relevant Intermediaries involved the Project Steering Group	25	25 38 individuals registered or 26 organisations
Newsletter sign-ups	Number of active email addresses included in the CRM newsletter circulation list	300	543
Networking and other professional training or education	Networking, workshops and training for a professional and apprentice audience will be provided as part of this project	1,000 individuals trained	2,395 known audience (including those registered for the final conference)
Number of businesses attending presentations	Organisations that have attended events where project presentations have been given	600	841
Number of organisations consulted in the development of policy recommendations	Number of industry experts from Government, trade associations, academia and the electricals industry consulted for B3 deliverable	No target defined	31

2.4. After LIFE Engagement and Knowledge Transfer Activities to Promote Replication

Consumer engagement and value chain knowledge transfer are instrumental to the replication of project activities and, as such, form a core element of the CRM project's After-LIFE plan. Within this plan, each project partner has made commitments for continued engagement and promotion activities, providing guidance and support for CRM collection, re-use and recovery, and dissemination of the project outputs, core messages and communications tools (as listed below):

- Noticeboards
- Trifold brochure

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- Pop up banner
- Website
- Case studies
- Fact sheet
- Media pack
- Policy report
- Infrastructure report
- Monitoring and Evaluation report
- Infographic
- Twitter account
- LinkedIn group
- Generic project dissemination pack.

2.5. Further Actions Necessary to Promote Replication

A continued focus on WEEE collections and CRM recovery is critical for the achievement of the project aims, and ultimately, to the achievement of a circular economy across Europe. The CRM project has exceeded expectations in terms of reach and engagement during the project lifetime. Whilst project partners will continue to promote and act upon the results of the project after the project close (see After LIFE Plan for further details on this activity), the extent of the challenges and changes necessary to ensure effective recovery of CRMs go beyond the scope of this CRM project or its sphere of influence.

As stated in the project's Policy Recommendations report, there is a need to raise awareness of the importance of WEEE collections and CRM recovery amongst citizens and businesses; engaging consumers and waste handlers with targeted actions and campaigns highlighting the importance of proper disposal of CRM rich WEEE.

Further research is necessary to evaluate the most effective methods for targeting and delivering these campaigns, and to test the development and impact of behaviour change messaging and techniques. Specifically, consumers need better information regarding appropriate disposal options for WEEE particularly in relation to data bearing devices, behaviour change messaging to discourage hoarding, and to communicate the environmental and social impacts and benefits of WEEE and its appropriate disposal. The value chain requires guidance, support and tools to design and promote services to extend the lifetime of EEE and keep CRMs in circulation for longer, such as re-use, repair, leasing and collaborative service delivery models. For further information please refer to the B3 and B4 Policy and Infrastructure Recommendations reports.

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3. Infrastructure

3.1. Collections Activities

The primary aim of the CRM project was to demonstrate economically viable approaches to both the collection and recovery of CRMs that will increase the recovery of target CRMs by 5% by 2020, and that will continue to increase CRM recovery to 20% by 2030. The vehicle for this demonstration was delivery of several industry trials, which tested a range of collection and recovery mechanisms, together with detailed analysis of the material, economic and socio-economic outcomes from the trials.

As noted previously in this report, 5 trial hosts were engaged to delivery trials in each the UK, Germany, Italy and the Czech Republic which tested 14 different collections and 7 innovative recovery methods. Detailed information regarding these trials can be found in the individual trails and summary reports. Table 3.1 below provides a summary of the trials collection activities and indicates the extent of engagement undertaken.

Table 3.1: Summary of Collections Trials Activities

	Collection Activity	Location	Trial Host
1	Retail take back in charity retailer	Greater Manchester (UK)	Axion Consulting
2	Retail take back with major electrical retailer	Greater Manchester (UK)	Axion Consulting
3	Retail incentivised returns	York and Leeds (UK)	Axion Consulting
4	Employee amnesty events in Business to Business WEEE collections	Various locations across Scotland and Northern England (UK)	Re-Tek
5	Primary school collection hubs	Aberdeenshire (UK)	Re-Tek
6	University Halls of Residence collection hubs	Glasgow, Edinburgh, Newcastle, Durham (UK)	Re-Tek
7	WEEE bins at recycling centres specifically for re-use	Kilmarnock and Cumnock (UK)	Re-Tek
8	Collection events in city public squares	Milan (Italy)	Ecodom
9	Primary school collection hubs	Milan (Italy)	Ecodom
10	Static WEEE bins in 2 Co-op stores	Milan (Italy)	Ecodom
11	Primary school collection hubs	Herford (Germany)	Recycling-Börse
12	Kerbside household collections	Herford (Germany)	Recycling-Börse
13	Retail collection hubs	Herford (Germany)	Recycling-Börse
14	Mobile collection units in areas unable to have permanent collections	Prague (Czech Republic)	ASEKOL a.s.

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As shown in Table 3.2 (below) the trials were successful in collecting the products deemed as priority (due to their high CRM content). All the trials collected consumer electronics and ICT, and three of the trials collected display equipment.This enabled testing of each of these product types in the subsequent recovery trials.

Table 3.2: Summary of the Priority Products Collected

	Collection pieces	Collection kg	Re-use pieces	Re-use kg
Asekol Display equipment	17	91	0	0
Asekol Consumer electronics	508	399	0	0
Asekol ICT	445	566	4	8
Asekol Gadgets	273	153	4	5
Axion Display equipment	3	15	3	15
Axion Consumer electronics	63	81	19	35
Axion ICT	236	599	88	294
Axion Gadgets	142	185	51	89
Ecodom Display equipment	26	126	11	52
Ecodom Consumer electronics	561	441	115	173
Ecodom ICT	545	742	181	250
Ecodom Gadgets	272	188	89	40
RecyclingBörse Display equipment	60	126	1	52
RecyclingBörse Consumer electronics	209	441	22	173
RecyclingBörse ICT	422	742	22	250
RecyclingBörse Gadgets	122	188	3	40
Re-Tek Display equipment	205	958	132	628
Re-Tek Consumer electronics	31	54	8	3
Re-Tek ICT	589	2416	90	353
Re-Tek Gadgets	222	269	36	57
Total Display equipment	311	1680	147	701
Total Consumer electronics	1372	1388	164	258
Total ICT	2237	5182	385	911
Total gadgets	1031	848	183	191

Together the trials collected over 43 tonnes of WEEE of which 9.9 tonnes would not have been collected had the trials not been conducted, for the C1 evaluation work the 9.9 tonnes of product was used The overall amount of WEEE collected across all the trials was higher

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than what was included in the project evaluation. Asekol's collections via stationary containers and collection yards, as well as Ecodom's collections in grocery stores and one of the two school collections were not assessed, as it was not possible to gather data from these trials on a product-specific basis.

Table 3.3 (below) shows the tonnages collected by collection type for each of the trial partners.

Table 3.3: Volumes of WEEE Collected by Trial Partner

	Axion	Re-tek	Ecodom	Recycling-Börse	Asekol	Total
Instore Takeback	0.7					**0.7**
Schools/University Halls		102	943	2629		**3674**
Mobile Containers/Bring Banks			2615		1659	**4274**
Stationary Containers/HWRCs		4226			9058*	**4226**
Public Events			2008			**2008**
Collection Yards					17664*	**0**
B2B		1246				**1246**
Social Enterprise		621				**621**
Household Collections				285		**285**
Total	**0.7**	**6195**	**5566**	**2914**	**28381**	**43056.7**

*Only the proportion of additional tonnages collected were included in the trials' evaluation

3.2. Post Project Replication of Collections Trials

Through discussion with the trials hosts, the CRM project has identified the following on-going collections activities and associated benefits that have occurred as a direct result of the project:

- **Italy -** COOP stores in Milan have continued to use the bring banks for small domestic appliances after the project trials, and Stena has continued testing of waste flat panel displays (FPDs) for re-use, resulting in one FTE post being created
- **Germany -** The ReBag collection scheme is being continued successfully, currently in early stages but collections are growing. School collections are gaining momentum with the waste management advisor of the local municipality (city of Herford) visiting RecyclingBorse to discuss the CRM project work. They are looking for solutions and actions to increase the collection rate towards 65% and are keen to look at replicating the Schools Olympics work that was carried out as part of the projects trials work. The Municipality have also encouraged Recyclingboerse to participate in the "week of

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waste prevention" taking place 16-24 November 2019 by following-up School collections.

- **Scotland** - Following on from the work carried out within the CRM project, the collection infrastructure remains in place at Strathdon School for IdeaTek (a social enterprise based in Aberdeenshire) to provide training and employment opportunities for adults with learning disabilities. The Re-Tek team have also secured funding to widen the collection infrastructure at a HWRC in Scotland and will look at the feasibility of installing containers at HWRCs and within community centres to collect ICT and Small Domestic Appliances (SDAs) for re-use. XS Resources (the Community Interest organisation set up by Enscape, CFINE (a food redistribution charity) and Re-tek have established a successful partnership to collect redundant ICT equipment from businesses in the NE of Scotland. Organisations arrange donations online (https://www.xsresources.org/contact) which CFINE collects and stores for transfer to Re-tek. Once collected, Re-tek process and sells for re-use, providing a rebate to CFINE to help stock into their food bank operations.
- **England** – as the result of networking at the mid-term CRM event, British Heart Foundation and Knowhow are working together to dispose of electrical items BHF are unable to sell or that didn't pass their functionality tests. This has been rolled out to 81 stores (pairing up BHF stores with their location Curry PC World store), with another 48 planned to roll out this year.

As these activities fall outside of the scope of the CRM project, assessment of their socio-economic benefits has not been presented, but presumably the net-benefits would be similar to those evidenced through the trials and justifies the continuation of these activities.

3.3. Scaling up of Collections Activities Across the EU to increase CRM Recovery

Whilst it was reported the collection methods utilized in the German trial could be rolled-out in other places as an additional measure to existing local WEEE collections, viability would be dependent on local conditions. The collection of CRM rich mobile phones and other small devices can be enhanced by offering more convenient collection solutions. The commercial viability of these methods was evaluated and showed that combined and existing methods like the clothes collection offered more positive results. In contrast, Asekol has determined that re-use from the B2C WEEE stream is not feasible in the Czech Republic at this time. These findings highlight the importance of understanding and planning in relation to local market conditions. There are municipal and national requirements which need to be considered before replicating such activities; there is no 'one size fits all' solution.

The proportion of re-usable products collected in the trials differed significantly, from 0% to 60%. Similarly, the content of CRMs and therefore the environmental resource savings varied depending on the products collected and end destination. For example, analysis showed that the material consumption per kg of products collected differed from less than 5kg up to 30kg,

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dependent on the product collected. These results underline the necessity for an in-depth understanding of collection and re-use activities and their environmental impacts (e.g. which products are collected best via which collection method; which are re-usable and more valuable from an environmental perspective).

Importantly, the trials findings also highlighted the value of focusing on CRM-rich products when planning and replicating re-use and collection activities. For example, the trials indicate that collection of high value products (that can be resold with little or no repair) as economically as possible (via a retailer) could offer the most effective means of increasing CRM recovery. However, further work is necessary to investigate any additional costs that should be included in cost models (i.e. opportunity costs from the loss of floor space) and to assess whether economies of scale in both collection and recovery could increase the effectiveness of retailer take-back.

A key insight from the collection trials was that collaborations with the charity sector are effective at increasing collections of WEEE. Retailers that are part of consumer's everyday habits (e.g. small convenience stores) offer an economical way to collect small WEEE from consumers. Trusted retailers may also give consumers more confidence to handover appliances where data security issues are greatest (e.g. smartphones) than charities. In the UK trials, this also increased the economic viability of collections as the items returned had a relatively high average value.

The trials also demonstrated that while collections in schools were time consuming to implement, they were very effective at collecting high volumes of WEEE. Although collections in public spaces were not as effective in terms of volume of WEEE collected, they were very effective at raising consumer awareness; testing over a longer time frame may result in improved performance in relation to average volumes of materials collected and cost effectiveness. Again, these proved more cost effective when partnership arrangements were made with charities to facilitate collections and re-use. Close to home collections, through distribution of bags or boxes, were considered convenient by consumers and were more effective at reducing the disposal of WEEE in residual household waste.

Replication of the trials could be carried out in regions where the current collection ratio of small CRM-rich items is not yet matured. These replication activities could deliver a significant added-value to increase knowledge regarding the efficiency and effectiveness of the methods done under various conditions and environments as well as considering more specific investigations, e.g.:

- Rural versus urban areas;
- Monitoring the distribution of bins and the returns in patterns (districts, streets, housing estates);
- Countries and areas with a long-term versus short-term culture of separate collection.

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3.4. Economic and Environmental Evaluation

The following table shows the costs and revenues for the different trials, in total as well as relative figures per collected kg of CRM rich products. For the trials in Italy, the income figures have been estimated using the data from Germany. For the trials in UK by Re-Tek, average costs for the different trials have been indicated by the trial host. For all other trials indicated costs by the trial hosts have been used to calculate costs per kg.

Table 3.3: Costs and Revenues

		Asekol	Recyclingbörse			Ecodom		Axion		Re-Tek
		Asekol: Mobile Containers	Recycling Boerse: Schools	Recycling Boerse: Re-Box	Recycling Boerse: Re-Bag	Ecodom: Schools	Ecodom: Market Squares	Axion: John Lewis	Axion: BHF	
Costs (Euro)	Investments/ permits	7000		5400	5000	410			200	
	Media	3000	800	930	300	2000	7236	300	4000	
	Labour costs	32000	4600	1600	6000	2590	4963	200	200	4660
Revenues, in Euro	Re-use	304.78	417.5	55	270	78	258	1633	1240	1338
	Recycling	146.99	201.35	5	15	38	125			
Collection in kg		1570	2134	95	163	399	1321	66	349	3477
Costs per kg, in Euro		26.75	2.53	83.47	69.33	12.53	9.23	7.58	12.61	1.34
Revenues per kg, in Euro		0.29	0.29	0.63	1.75	0.29	0.29	24.74	3.55	0.38

Only one of the trials analysed shows a positive net economic benefit, for all other trials significantly higher costs than revenues have been indicated. The figures for the one economically viable trial (Axion in combination with John Lewis) show that on the one hand, valuable products were collected (almost 25 Euros per kg compared to an average value with less than 1 Euro), but on the other hand labour costs were low due to cooperation with the external partner (whose costs were not included). In general, it has to be taken into account that many of the costs are not fully accounted for: e.g. the cost of lost sales from a retailer because they devoted space to CRM collection.

Overall, the results show how context dependent the potential to save resources or to reduce the climate impact are and results can vary greatly depending on which impact categories are considered. Even if the findings have shown that the increase in collection consistently contributes to the environmental protection, since resources and CO_2 emissions are saved, targeted action in the sense of maximising the potential for environmental benefits is not

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possible without prioritising impact categories. Furthermore, there are considerable uncertainties in the calculation of both the quantities of CRM and the environmental indicators.

The costs per collected kg of CRM relevant products differ significantly between the trials, ranging from 1.34 Euro/ kg to 83.47 Euro/ kg. These differences can be explained by:

- The share of necessary investments: the innovative trials by RecyclingBörse required significant investments in new equipment leading to high costs per kg.
- Involvement of internal and external staff in the trials. For the Czech trials, necessary efforts have been recorded very thoroughly and the trials were handled as separate projects. Lower costs have been indicated wherever it was possible to include the trial activities into on-going collection activities (e.g. the combined collection of WEEE and textiles).
- The role of (expenditure for) awareness raising activities; e.g. the trials in Italy have been accompanied by very detailed information campaigns, raising significant awareness for the issue of CRM recovery and related environmental benefits. These costs per kg might be reduced if the trials would be upscaled.
- The revenues per collected kg differ between the trials: Those trials with high income streams managed to collect relatively new products that still have a high resale value.

Overall, the key success factor is the sale of second-hand products which, based on the extension of the use phase of products, leads to a reduced demand for CRM, if these second-hand products replace new products.

The analysis shows that the economic viability clearly depends on successful coordination with other collection activities (e.g. the combined collection of WEEE and textiles) or the cooperation with existing infrastructures (e.g. household recycling centres) or the retail sector. Additional collection infrastructures just for CRM rich products will be difficult to establish due to insufficient economic viability and because convenience is essential to maximising capture of additional products. Learning curve effects might lead to more positive effects in the long run, as for example, the collection activities improve and become more efficient, economies of scale may be achieved if the collections increase, and new products may also be included so that running costs / item could reduce. At the same time it should be considered that the average value of products might decrease if the ‘good products’ are returned to begin with, motivated by (for example) communications on positive environmental benefits, and that the quantity of products might decrease over time if initial awareness raising encourages early uptake followed by a gradual decline in use of the service.

The results of the environmental assessment show how context dependent the potential to save resources or to reduce the climate impact are and results can vary greatly depending on which impact categories are considered. Even if the findings have shown that the increase in collection consistently contributes to the environmental protection, since resources and CO_2 emissions are saved, targeted action in the sense of maximising the potential for

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environmental benefits is not possible without prioritising impact categories. Furthermore, there are considerable uncertainties in the calculation of both the quantities of CRM and the environmental indicators.

3.5. Recovery Activities

Seven recovery methods were tested by the trial hosts, which targeted one or more of the following elements: graphite; cobalt; antimony; tantalum; Rare Earths; Platinum Group Metals; gold; and silver. Table 3.4 (below) provides a high-level overview of each recovery trial. Further detail can be found in the trial summary reports.

Table 3.4: Overview of Recovery Trials

Recovery Activity	Target CRM	Scale	Location	Trial Host
De-soldering of PCBs and concentration of components	Cobalt, Antimony, Tantalum, Rare Earths, Platinum Group Metals, Gold and Silver	Laboratory	Greater Manchester (UK)	Axion Consulting
Electrochemical deposition from PCB solutions	Cobalt, Gold and Silver	Laboratory	Paisley (UK)	Re-Tek
Extraction from disassembled Lithium Ion batteries	Graphite, Cobalt	Laboratory	Colico (Italy)	Ecodom
Comparing batches of collected WEEE through an established precious metal recovery system	Platinum Group Metals, Gold and Silver	Industrial	Angiari (Italy)	Ecodom
Tantalum extraction from capacitors	Tantalum	Laboratory	Hamburg (Germany)	Recycling-Börse
Neodymium extraction from magnets in hard disk drives	Rare Earths (Neodymium)	Laboratory	Hamburg (Germany)	Recycling-Börse
Increasing concentrations of CRM for smelting via wet separation and electrostatic separation	Rare Earths, Platinum Group Metals, Gold, Silver, Copper and Aluminium	Laboratory to Industrial	Jihlava (Czech Republic)	ASEKOL a.s.

The trial activities were largely focused on innovative, proof of concept methods for the recovery of CRMs. Therefore, extrapolating data to determine the costs and benefits at an industrial scale is extremely complex and could be highly unreliable. Indeed, the costs of many of the CRM recovery methods trialled were high in comparison to industrial recovery costs precisely due to their low TRL but illustrated that commercial feasibility would require a concentration of CRMs to achieve economically viable economies of scale.

In addition to demonstrating the need to concentrate CRMs in collection activities, the trials also confirmed the need for quality collections, to prioritise re-use to maximise income and minimize both the loss of CRMs through damages, costs, and additional environmental impacts incurred through recovery processes.

Table 3.5 (below) provides the main considerations for the replication and upscaling of recovery methods trialled.

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Table 3.5: Requirements for Replication of Recovery Trials

Trial Host	Trial Description
Czech Republic – Asekol	For the fine ferrous fractions hand picking or the combination of baking + milling + sieving was most successful but not necessarily suitable for upscaling to an industrial application. Plastic fractions were suitable for increasing recovery of CRMs after primary treatment through the shredder line. Milling and electrostatic separation was the most successful of these methods. Asekol's treatment partner for the trials, Enviropol, continues to analyse some output fractions for varying qualities of Precious Metal content. Further work is needed to scale up the other types of refinement. For some of the fractions they were able to extract more CRMs and RE's albeit not to a saleable level. Asekol did determine that some processes were feasible, with upscaling to industrial levels (and a lot of capital investment). Should separate collections be mandated, then scalability for treatment and/or re-use could potentially be achieved.
Germany - Recycling-Börse	The success of the trial of tantalum recovery by bio-leaching warrants further research to develop this innovative approach to a higher TRL. Significant research funding is necessary to improve the effects of the agents (bacteria and/or fungi), the efficiency of process flow and to make the tantalum concentrates ready for feeding into production processes. The replication of the recovery of neodymium magnet material is still a topic in applied research, but the TRL is already at a level where implementation into an industrial scale can be achieved short-term. Awareness must be raised to bring together the related parties along the value chain in Europe to set-up a competitive solution compared to the current China route for the import of magnets.
Italy – Ecodom	Re-use of flat panel displays demonstrated the commercial viability of the activity and could be replicated on a larger scale with the support of the municipal and national regulators. The treatment operator needed to export the REEE to other E.U. countries as it was not currently permitted re-use under Italian rules. The Precious Metal Recycling successfully increased CRMs recovered by treating SDA in batches of high-CRM versus low-CRM. Labour costs to separate these after consolidation at the treatment operators would be high, so source separation recycling centres would be necessary. The battery recovery trials demonstrated that extraction of cobalt and graphite are possible from rechargeable lithium batteries, however the outputs were such that even with scaling up, they might not prove commercially viable. Furthermore, the investment to a large-scale treatment operation would be prohibitive for most recyclers.
UK – Axion	It would be most appropriate for dismantling to be carried out at an existing WEEE dismantling facility with suitable facilities, equipment and technical ability. Operator training would be needed for the dismantling of new item types, such as mobile phones.

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	If the Itrimex depopulation route was chosen for removing circuit board components, design of a large-scale process would be required. The Itrimex route has been validated on a pilot scale but to achieve industrialization further engineering work would be required. As the Itrimex depopulation process was unable to remove many of the components, and the solution reacted vigorously with large pieces of metal on the boards, alternative approaches may be needed; this could involve modifying the depopulation solution to attack more component bindings or using a thermal depopulation process. Either depopulation method would require further agitation to remove components that have not dropped off the boards. This could be done using a tumbling drum or similar. By using size, magnetic, and density separation, the components can be concentrated into specific fractions. Based on this work, the most beneficial separations are suggested to be: • Screening at 8 mm, 3 mm and 0.5 mm • Magnetic separation of 3-8 mm fraction • Density separation of magnetic 3-8 mm fraction at 2 and 3 SG
UK – Re-tek	Some of the proof of concept laboratory experiments, demonstrated high recovery rates of the elements of interest. However, further laboratory work is required before these separation techniques would be suitable for use within a commercial environment. Prior to roll-out in other places, there is also specific research that that would need to be carried out for the particle size distribution, this includes the following (which would form part of the next steps): • Optimising particle size • Reducing contamination between samples • Optimising the shredding and grinding stage to aid separation of metals from the PCB. Hydrogen sulphide is expensive to source and requires significant health and safety procedures to be put in place, however it could be generated from a waste or by-product process to make the method more environmentally and economically sound. The precipitation process indicated positive results, large scale improvements to the sulphide precipitation could result in a more commercially viable option to the labour-intensive lab-scale approach that was adopted during this study. The recovery rates of the EC Cell were very high and the minimum and maximum threshold concentrations were very good. However, the selectiveness of the EC Cell is not sufficient to recover a single element out of a multi-elemental solution. For a complex waste stream, like PCBs, there would need to be multiple steps undertaken, before the EC Cell could be utilised. This decreases the economic viability of the EC Cell for recovering individual elements.

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3.6. Scaling up of Recovery Activities Across the EU to increase CRM Recovery

With respect to recovery of CRMs, treatment operators will only consider doing so if it's commercially viable. The recovery trials within the CRM project were small in scale, but re-use of flat panel displays proved fruitful, as did treating CRM-rich WEEE in concentrated batches and bio-leaching separation techniques. Should separate collections WEEE be mandated, then scalability for treatment and/or re-use could potentially be achieved. However, further research and industrial pilot scale projects will be needed – replication studies could empirically support the results of the project and fill research gaps.

There is potential to scale-up some of the recovery technologies that achieved positive outcomes during the trials, where it was demonstrated that the technology worked successfully at a very small scale. The laboratory nature of the recovery trials means that conclusions about commercialising the technology on a larger scale could not be drawn. Further trials could look to demonstrate viability on a larger scale.

Bio-leaching has shown high potential recovery rates but still lacks commercial viability. However, considering the significantly reduced environmental impact of bio-leaching compared to conventional pyrometallurgical processes, the real costs are lower, and the operational risk level is lower than chemical leaching. Consequently, the prospect of bio-leaching especially in developing countries is encouraging. To encourage private companies to adopt methods of bio-leaching, incentives e.g. in the form of tax exemptions or other funding, will be necessary.

Therefore, national and local governments as well as non-governmental organisations should be partners in R&D projects carried out by governments or companies that encourage the adoption of sustainable methods like bio-leaching. The private sector must be made aware of the feasibility of adopting this method versus the traditional metal recovery methods.

3.7. Collections and Recovery Conclusions

3.7.1. Collections

All estimates come with the caveat that these were trials which are likely to become more efficient over time (i.e. capturing more material at lower cost), while the seasonality of EEE purchases and WEEE disposal may mean that the collection figures are optimistic in relation to what would be captured over the course of a year. It is also challenging to understand what the counterfactual is, i.e. if these items of WEEE would have been collected elsewhere via a different route.

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To scale CRM collections, longer term and larger retail-based trials should take place to understand capture rates over time. Furthermore, the impact on retail outlet's financial viability should be analysed and modelled. For example, to determine if the small WEEE collection point increase or decrease footfall, spend per consumer/square foot versus the baseline. Research should look at the role that back-of-store recycling collections at supermarkets have as a starter point.

Collection costs may be further reduced through the design of a harmonised collection point with consistent labelling. This cost was not analysed as part of the project but is likely to yield economies of scale over time.

Fast tracking the roll-out of the collection scheme could be supported by a regional government. For example, by subsidising the collection scheme or revenue sharing scheme with retailers/recyclers.

3.7.2. Recovery

As per the Infrastructure Development report this will only be successful if the network of collection hubs (small WEEE collected by retailers) are plugged into the network of recyclers / re-use organisations. One suggestion would be a central body that could sort the small WEEE to ensure that equipment collected goes to where the most CRM value can be recovered or re-used.

At present the WEEE sorting infrastructure is not positioned to sort through large quantities of small WEEE. This may be a gap in the infrastructure that needs to be filled. This may require training employees to be able to quickly identify high/low value, broken/repairable small WEEE.

3.7.3. Ensuring Viable End Markets

It is no use for CRMs to be collected, extracted and recovered from small WEEE if no end market exists for them. In order for the infrastructure recommendations in this report to be successful there needs to be closer communication between CRM recovery firms and end consumers, i.e. the manufacturers who aim to use them in their end products.

Creating this link will ensure that recovered CRMs meet the manufacturers required specification. It may also result in longer term financial arrangements that could guarantee offtake of recovered CRMs and hedge underlying CRM price risk.

There are several ways in which the link between CRM recovery companies and manufacturers could be strengthened including: workshops/conferences, voluntary agreements, policy levers incentivising higher CRM recycled content, etc.

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Re-use end markets for small WEEE will require reducing search costs. One of the main barriers to achieving more re-use of small WEEE is trust and transparency - including trust in the abilities of the repairer and the quality of the repair and trust in the repairer to take care of the item. In addition, many repair centres for electrical goods are based in major urban centres where due to the economies of scale and the ready demand from individuals and business they can survive.

Options to counter these search cost barriers include, consumers being able to provide feedback on repair services, and counteracting the geographical limitation through postal repair/re-use, or re-engineering existing logistics so that transport and retailers can cater for higher amounts of small WEEE.

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4. Policy Development

4.1. Context

To facilitate WEEE collections and recycling, including re-use, and to maintain and grow membership of the Producer Compliance Schemes, there needs to be a level playing field, which is often brought about through policy and regulation.

The availability and efficiency of recovery infrastructure is influenced by many factors and complex interactions between policies and priorities. While some policies directly target CRMs, others indirectly influence CRM recovery through enabling or hindering implications. They often can be categorized by their pulling or pushing character. The former are policies that aim to pull the market in a certain direction for example by informing consumers about a product (i.e. creating demand) while the latter aims to push the market in a direction through for example enforcing bans on certain products (European Commission, 2018).

To achieve the objectives of CRM Recovery project and to investigate how the lessons learned from each of the trials could be transferred to other Member States, a comparison exercise was conducted using criteria from the Compliance Promotion Exercise.

Analysis of the individual situations of the four Member States where the collection and treatment trials took place was also conducted. Following this analysis, considering the variety of factors detailed in Section 5 of the B3 report, it was not possible to identify clear patterns or cluster of countries in a unique way. Therefore, reliable data analysis and economic modelling to determine how best to replicate any one policy recommendation in other member States was not possible. This was largely due to inconsistencies within the available data collected from Member States by Eurostat. Nor was it possible to determine the ease of set up or impact of introduction. Understanding what the most impactful replication opportunities are is a challenging task due to data from various Member States not being consistently collected within Eurostat statistics. A standardised pan-European WEEE data collection methodology would ensure far more accurate and consistent statistics.

However, the trials demonstrated that issues underlying the lack of CRM recovery are prevalent across all trial regions and so pan-European recommendations were developed. These recommendations included:

1. **Redesign and harmonise WEEE collection infrastructure**
2. **Increase awareness amongst citizens and businesses**
3. **Create incentives for collection and recycling organisations**
4. **Continue innovation and research on CRM recovery and foster international collaboration**

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5. **Introduce CRM-specific requirements into standards**

All five policy recommendations are applicable to the four trial host nations as the clustering exercise (Section 5 of the B3 report) demonstrated that they were not dissimilar enough to require different policy measures, instead they shared common challenges in CRM-rich WEEE collection and recovery which requires EU-wide policy interventions.

4.2. Harmonised WEEE Collections Infrastructure

Almost all Member States are not yet able to reach the ambitious collection targets set for 2019 and onwards (65% Placed on Market or 85% Waste Generated) and collection of small WEEE is one of the key aspects to tackle. Thus, any action aiming at rethinking the collection strategy to foster collection can usefully be transferred or replicated across Member States to help meet the requirements of WEEE Directive (2012/19/EU).

The first step to ensure CRMs are recovered (or kept in the economic loop through preparation for re-use activities) is to secure their separate collections for high-CRM and/or WEEE suitable for re-use, which, if mandated could lead to a greater recovery of CRMs or extend the life-cycles of WEEE through re-use.

With regards to the availability of collection infrastructure, only Germany reported checks on the availability of treatment infrastructure by competent authorities. Both the Czech Republic and the United Kingdom reported that checks on the availability of treatment infrastructure are not monitored, and although there was no response from Italy regarding the same, it can be assumed that the availability of collection infrastructure is also not officially monitored by local authorities at the National level, as waste permits are under the remit of individual regions.

A lack of an established network of registered and authorized/certified preparation for re-use operators emerged as a key barrier from the trials which is also in-line with trial participant's concerns regarding the data security of their devices.

Increasing EU monitoring capabilities for the management of WEEE exports would improve supply conditions both within and outside of the EU, alongside an increase to the cost of WEEE for export. Similarly, increased monitoring and visibility would see items that have been deemed suitable for re-use exported as opposed to waste being illegally transported under the guise of recycling.

The recovery of CRMs is dependent on the quantity and quality of the WEEE collected. Many of the trials highlighted that when working with known and trusted brands, citizen's security concerns were offset. Similarly, when high quality whole (undamaged) items were sent for

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recycling, the recovery phase was easier as the products could be disassembled more quickly. As such, harmonised, conveniently positioned and secure collection points are required to ensure CRM-rich WEEE can be separated out and remain in a good condition for re-use or ease-of-disassembly purposes.
Increasing EU monitoring capabilities for the management of WEEE exports would improve supply conditions both within and outside of the EU, alongside an increase to the cost of WEEE for export. Similarly, increased monitoring and visibility would see items that have been deemed suitable for re-use exported as opposed to waste being illegally transported under the guise of recycling.

A continuation of CRM recovery research and knowledge sharing is required to scale-up the recovery activities from lab-based to commercial operations.

4.3. Increasing Consumer Engagement

The surveys highlighted that many citizens are unaware of how or where to recycle their unwanted electronics. Coupled with the fear of whether their data would be fully eradicated, and some inertia reported as “not getting around to it”, resulted in hoarding, whereby products are left at home rather than being recycled. Raising awareness is required to relay data security concerns and empower citizens to erase their own data. Taking devices to be recycled was regarded as a good thing to do, so that collection services will be used, provided they are convenient enough and concerns are addressed.

Many of the trials undertook marketing campaigns to accompany the collection activity including posters, leaflets and local radio advertising. These activities were effective as the amount of WEEE collected increased in the trial areas during the collection activities. The successful marketing materials and campaigns could be replicated across other Member States to avoid duplicating efforts in creating new marketing materials and campaign materials from scratch.

To encourage citizens to use collection points, access to them must be convenient and they must be easy to use. Each trial-host nation had different collection activities tailored for the cultural conditions of the area. For example, collection bins in Italy were placed in squares where the local community congregated on particular days. This method may be replicated in similar nations. Overall looking at each of the collection trials, the highest volumes were collected when infrastructure was located alongside existing arrangements, for example using a recycling centre or recognised collection point. In such cases it was possible to collect equipment over a longer period of time compared to the events that were organised. This had the effect of maximising the quantity collected, by extending the time spent collecting it and minimising requirements for additional infrastructure to facilitate the collections.

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4.4. Ensuring Viable End Markets with standards and incentivisation

Policy actions should aim towards providing a stable secondary material market to support and incentivize a secure financial framework, by using economic instruments to reduce investment risks for recyclers and the long-term feasibility of recovery technology through, for example, the development of standards on minimum production requirements, modularity or the labelling of product components. Specific guidance or requirements for CRM recovery are not currently outlined within WEEE legislation; the Circular Economy Package specifically mentions the need to prevent products containing CRMs from ever becoming waste but there is no guidance on how to recover CRMs from WEEE or on collecting WEEE to maximise potential recovery. To encourage CRM capture from WEEE, policies featuring circular economy or collection/recovery targets should include targeting CRMs specifically.

4.5. Continue Innovation and Research on CRM Recovery

A continuation of CRM recovery research and knowledge sharing is required to scale-up the recovery activities from lab-based pilots, to fully demonstrate the new technologies to the point where they are ready to be established as commercial operations. There is scope to increase recovery potential from the laboratory work already done, so that investment in further Research Development and Innovation is needed to move beyond very small-scale pilots. Demonstrating this potential will depend on being able to successfully replicate it given different conditions while maintaining or increasing the ratio of potentially recoverable CRMs. International collaboration to test and extend the CRM Recovery trials will be vital to achieve replication of results. To this end, wide dissemination of the results of the CRM Recovery project has raised awareness of the potential discovered during the recovery trials among audiences that include potential future collaborators.

4.6. Conclusion

As the EU is largely reliant on imports of CRMs from non-EU countries, it is important to ensure CRMs are recovered from WEEE so as so continue their circulation within European markets thereby reducing the need to extract more virgin resources. The three most prevalent barriers that would need to be addressed to increase CRM recovery from WEEE in the EU identified requirements to:

- Redesign the way CRM-rich WEEE is currently collected;

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- Raise awareness amongst citizens and businesses about the importance of and correct routes for recycling unwanted electricals; and
- Ensure recyclers and collectors were not disproportionally burdened by administrative duties when seeking to collect CRM-rich WEEE for material reclamation.

All five policy recommendations are applicable to the four trial host nations as the clustering exercise (section 6) demonstrated that they were not dissimilar enough to require different policy measures, instead they shared common challenges in CRM-rich WEEE collection and recovery which requires EU-wide policy interventions.

Policy actions should aim towards providing a stable secondary material market to support and incentivize a secure financial framework, by using economic instruments to reduce investment risks for recyclers and the long-term feasibility of recovery technology through, for example, the development of standards on minimum production requirements, modularity or the labelling of product components.

Analysis following the policy literature review highlighted that the Eco-design Directive itself may not be the right vehicle for CRM capture, but that a more generic approach to promoting eco-design for CRM containing products may be more effective, e.g. through EPR, or the EU Ecolabel. Similarly, the policy literature review revealed that weight-based collection and recovery targets are not suited to CRM-recovery as they may encourage nations to prioritise heavier items to more quickly achieve the targets as opposed to seeking out the valuable CRMs from WEEE.

There is no platform available for WEEE experts in the industry to exchange knowledge or seek out collaboration activities. An online platform to foster continued research efforts, alongside a continuation of available funding from the Commission is recommended to ensure experts in the field can progress CRM recovery within the EU.

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5. Achieving the Project Objectives

5.1. Introduction

On project completion, outcomes from the project can cease to take effect, they can continue to deliver impact, and in some cases, where there have been notable successes, they may be extended or ramped up.

WRAP research has previously considered lifetime outcomes from projects of different kinds, including whether participants / beneficiaries were likely to extend the activities they had undertaken, and whether they were likely to spread to other organisations. The lifetime outcomes study surveyed project participants / beneficiaries several years after the initial support to find out about the outcomes from the support after it ceased. The report provided growth curves for clusters of supported activity over a 5-year timeline (up to 10 years for projects that had received direct financial support only). A discontinuation rate was also established.

For this report, the Wuppertal Institute assessed the potential for viable approaches to increase the recovery of target CRMs from WEEE by 5% by 2020 and by 20% by 2030. The results of the collection and recovery trials were reviewed, and examples used to demonstrate potential recovery rates in the short and longer term. Although the examples provided are illustrative and not intended to represent future recovery rates for the trials overall, they do show how it is possible to achieve the targeted recovery of CRMs over time.

On-going impacts may result from a number of situations. Replication is considered to occur where a non-beneficiary, or non-trial organisation, is influenced to take similar actions to those taken during the trials, by beneficiaries or actions demonstrated by the project's activities (in particular, taking forward and replicating findings from R&D feasibility studies). This may be particularly pertinent for activities designed to transform markets, where funded delivery activities stimulate actions which are replicated across whole markets. Replication in this sense depends on dissemination of the results of a project to a wider audience, and on delivery of future collaborative research, development and innovation projects.

Replication, outside participant organisations, can also be explored with beneficiaries but typically involves looking more widely. Sections 3.2 and 3.5 in this report identify aspects of the collection trials, and recovery trials, respectively, which might be suitable for replication. Modelling the 'landscape' in which the project is situated can also provide an indication of potential. A growth curve may be expected for successful outcomes but the extent of growth, the timescales involved, may vary widely depending on a variety of factors, for example:

- Size of potential market

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- Macro-economic factors
- The nature of the original support provided
- Strength of evidence in favour of the activities involved in the trials
- Enthusiasm and willingness of trial partners in communicating the successes and failures of the activities undertaken.

In Winning Moves' lifetime outcomes study for WRAP (2009-10), interventions were organised into clusters and lifetime growth curves up to 5 years sought to establish whether realisation, roll-out, and replication might be expected to occur. Previously impacts had been assumed to decline over time until depreciation brought them to zero after 5 years. The lifetime outcomes study sought factors for interventions (projects) of particular types such that future replication might be predicted based on what had been achieved in earlier projects which had had time to demonstrate what would happen once delivery ceased. However, growth curves were not established for feasibility / R&D projects as these projects were not intended to achieve ramp up / down or because there were too few respondents. There was considered to be some potential for replication of feasibility / R&D, but a growth curve was not modelled.

5.2. The Status Quo

The overall objective of the CRM Recovery Project was to demonstrate viable approaches to increase the recovery of target (CRMs) from WEEE by 5% by 2020 and by 20% by 2030. These ambitious objectives have been based on a baseline assessment of the current recycling chain efficiency that currently leads to insufficient recovery results for many critical raw materials. Figure 5.1 includes an illustration of the status quo, taking the example of gold recovery from printed circuit boards installed in PCs. Despite a very high recovery rate in the final step of smelting the material, the overall efficiency is only 28% due to the losses during the collection (48% yield) and pre-treatment phase (90%/ 50% yield). The figures are considerably lower for other critical raw materials like tantalum for which also during the final recovery large shares of the material are lost.

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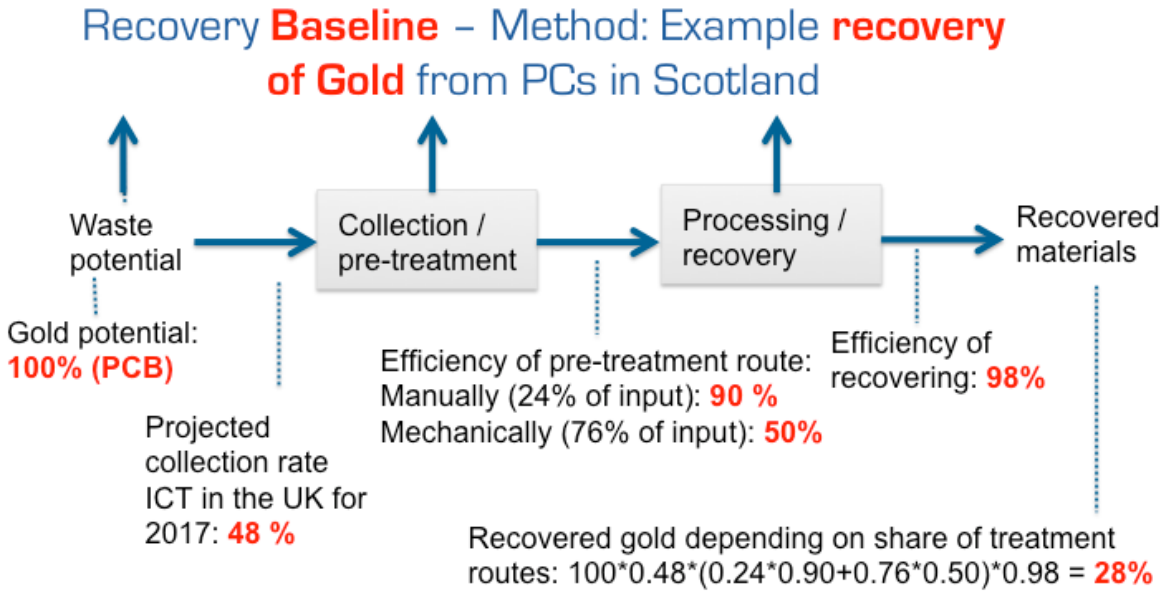
Figure 5.1: Recycling Chain Efficiency for Gold from PCs



5.3. Short Term Increase: 5% by 2020

In order to demonstrate viable approaches for a short term increase of 5% during the project duration, various innovative collection approaches have been initiated and analysed (the methodology for which is discussed in detail in the C1 – Monitoring and Evaluation report) which would increase the amount of CRM rich products recovered. Considering Figure 5.1 above once more, the example of recovering gold from PC's in Scotland illustrates that one way to achieve the short term target for the overall recycling chain efficiency would be to increase the collection rate from 48% to 50.5%, an increase of 5% over the projected collection rate for ICT in the UK for 2017.

The following

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Table 5.1 shows (taking the example of gadgets) that this target of +5% could have been achieved by at least seven of the trials (although the +126% for the Axion British Heart Foundation trial should be considered as an exceptional outlier). The economic viability will depend on further economies of scale and learning curve effects as efficiency improves over time following successful adoption and wider take-up of improved ways of doing things, as well as a harmonized regulatory framework.

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Table 5.1: Results of the Baseline for Gadgets

Represent the share of products, which otherwise (without the activity) would have been re-used or recycled

Old WEEE + the share of products, which could be re-directed with the activity (and would otherwise have been put in the rubbish bin)

Target group: people participated at the activity…	Old WEEE collection rate (pcs-%)	Potential WEEE collection rate (pcs-%)	Increase (%)
Asekol: general	53.38	61.86	15.89
Axion: Dixons	65.71	77.14	17.39
Axion: BHF	37.25	84.31	126.34
Axion. John Lewis	45.83	55.55	21.21
Ecodom: general	54.75	61.16	11.71
Recycling Boerse: ReBox	32.53	32.53	0.00
Retek: Halls	54.48	66.58	22.21
Re-Tek: B2B	55.92	67.77	21.19

5.4. Long Term Increase: 20% by 2030

There is a good chance to increase the CRM recovery by 20% until 2030 due to improved collections across Europe by spreading and implementing the project findings and methods of WEEE collection. However, there is certain additional potential for increasing the CRM recovery by implementing early-stage recovery innovations.

To demonstrate viable approaches for such a systemic improvement, various early-stage recovery innovations have been tested and analysed. Taking the example of tantalum, the end-of-life recycling rate so far has been estimated to be below 1% (see e.g. UNEP 2011). A combined implementation of the trial results for the collection phase (50.5% collection, 24% disassembly and 13% recovery rate from bio-leaching) would lead to an overall recovery rate of 1.4%; an increase of

42% compared to the current recycling efficiency of 1% (see Figure 5.2, below for this example). Tantalum may be an extreme, although probably not unique, example in terms of the potential to increase recovery. For gold, silver or copper, the current recovery rates are of course already significantly higher, thus the increase would be lower but nevertheless significant.

Increased recovery over time implies that activities are scaled up, but it can also mean that materials that are difficult to recover, are more effectively targeted. It can also mean that the recovery technologies improve.

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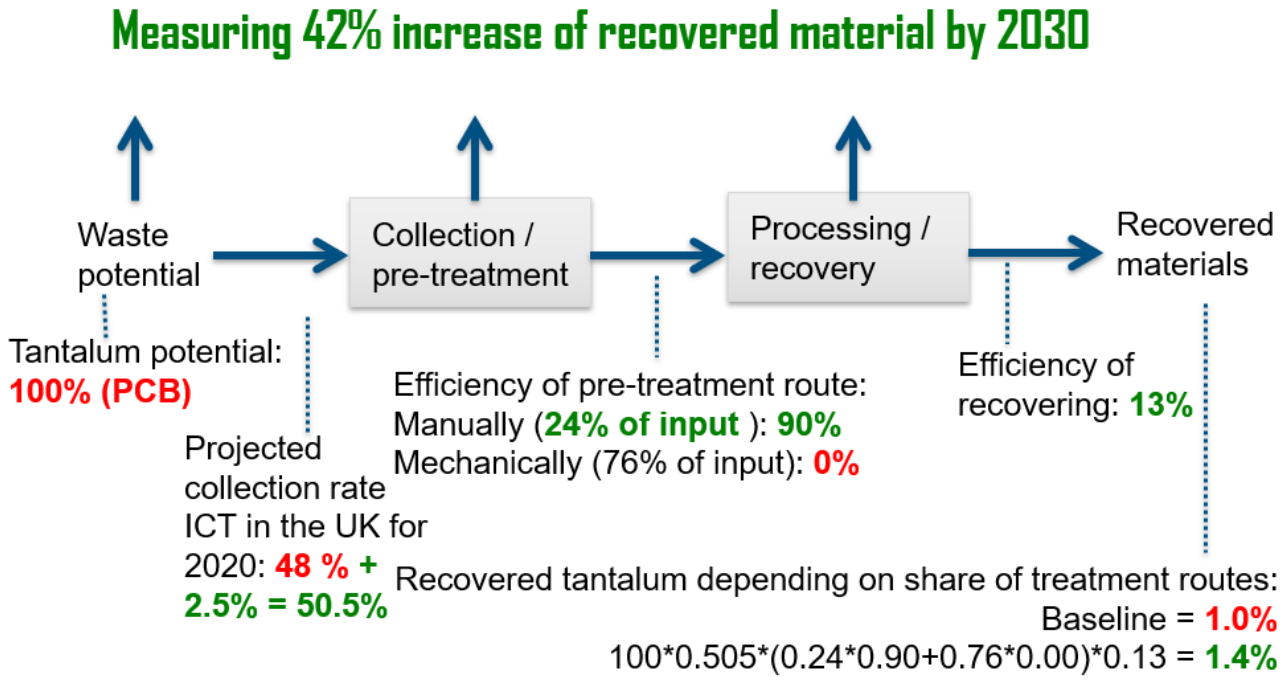
Figure 5.2: Recycling Chain Efficiency for Tantalum



5.5. Summary and Conclusion

Through this methodology the project has demonstrated viable approaches to achieve the project objectives to increase the recovery of target critical raw materials (CRMs) from WEEE by 5% by 2020 and by 20% by 2030 from the activities undertaken through the project collections and recovery trials.

However, evaluating the future potential impact of replication activities largely reliant on research and development, investment and the implementation of policy instruments to commercial scale, may be possible, but would be not be desirable due to the amount of uncertainty that would be associated with any estimates or projections provided.

This report has provided an overview of the activities undertaken during the project, methods partners and beneficiaries will utilise to promote their on-going replications, and further opportunities for replication through development of engagement, knowledge transfer, infrastructure development, innovation and policy instruments.

The report has highlighted a need for improved consumer engagement, as well as a need for investment in the scaling up of collections activities delivered through collaborative partnerships with public and charitable sectors, the need to mandate separate collections of

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CRM rich WEEE, to promote the viability of CRM recovery and a circular economy across the EU.

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