The Institute of Materials, Minerals and Mining

Introduction

The Institute of Materials, Minerals and Mining (IOM3) is a major UK science and engineering institution whose activities promote and develop all aspects of the materials cycle from exploration and extraction, through characterisation, processing and application, to reuse and recycling. IOM3 represents and supports over 18,000 individual members and draws on this breadth and depth of knowledge and experience to provide informed and impartial contributions to policy discussions.

Summary

To reduce the UK's environmental impact, create economic opportunities and maintain access to critical materials, e-waste should be minimised and better managed using the following principles, policies and learning:

- A well-designed extended producer responsibility framework that incorporates a modulated fee system, takes into account full life cycle impacts and encourages adoption of the waste hierarchy.
- Use and apply relevant learning from packaging extended producer responsibility and international experiences to inform decisions and foster alignment where appropriate.
- Incentivise more sustainable product design, incorporating life cycle thinking, that encourages product durability and utility. Supporting reusability, repairability, dismantlability, extractability and recyclability will facilitate the transition to a low carbon, more resource efficient economy.
- Drive change in product standards, incorporating the 'right to repair' and mandating that spare parts and adequate repair instructions are made available.
- Foster new and alternative business models that promote longevity and circular economy principles such as leasing or providing goods as a service.
- Collect and harness high quality data and flows for electrical and electronic equipment and waste electrical and electronic equipment across the full value chain.
- Greater consumer engagement and clearer information and labelling to help individuals make better environmental decisions and prevent hoarding, increasing the quantity and quality of waste electrical and electronic equipment available for collection.
- Collaboration and involvement from stakeholders across the full value chain including full consultation based on life cycle analysis to avoid unintended consequences.
- Alignment of policies across the UK and with the standards of our key international trading partners.

Throughout this report the terms electrical and electronic have been used interchangeably.

Implementing a Circular Economy for Electronic Goods

What steps are being taken to move towards a circular economy for electronic goods? How can the UK Government support this transition?

Electronic goods comprise a variety of products from TVs and cameras to IT equipment and mobile phones. Each product type is compositionally complex and made up of a mix of materials such as plastics, ceramics, glass and metals.

To transition towards a circular economy steps should be taken to keep products and their materials in circulation at their highest value for as long as possible. Following the waste hierarchy reuse should be prioritised, favouring modular design and upgradability, above recycling and recovery. This is particularly pertinent for high value-added goods such as electronics where much of the recoverable value lies in the components, parts and manufacturing value of the products.

Specific examples of steps being taken to move towards a circular economy for electronic goods include:

- FairPhone has developed a modular mobile device that is designed to be upgraded. Whilst the volumes of production have been comparatively small this demonstrates what is possible.
- Apple has invested in Daisy, a robotic system for automatically disassembling its own devices into parts to enable the recovery of valuable materials. At present, this is more of a demonstration system, however Apple has indicated a goal to move towards more significant materials recovery. Apple have included buy-back models into their sales channels and now sell used and refurbished products.
- Companies such as Grover have developed from the demand to rent rather than own electronics – such models encourage the reuse of electronics that might otherwise be disposed of prematurely as waste.
- There is significant use of electronics in server farms and cloud storage facilities and some (unable to specify due to confidentiality) are actively seeking to reuse hardware more and to redesign systems for upgradability.
- Companies such as Umicore in Belgium, Johnson Matthey in the UK and Mint Innovation in New Zealand and the UK are actively involved in the recycling of electronic waste using a variety of techniques. Mint Innovation uses microbes, very small living organisms, to extract metals such as gold and copper from waste devices. Flexible plant deployment allows the process to be used to recover metals directly in the towns and cities where the electronic waste is collected.
- PolyCE (post-consumer high-tech recycled polymers for a circular economy) is a project working to reduce the use of virgin plastics and enhance the use of recycled plastics in new electronic applications. The project aims to deliver eight electronic product demonstrators containing recycled plastic in 2020[1].

The most widespread steps taken so far to move towards a circular economy for electrical and electronic goods and reduce their impact on the environment have been based on the reduction of water and energy use. This is well demonstrated by the home appliance industry[2].

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[1] https://www.polyce-project.eu/

[2] Huisman, Jaco & Magalini, Federico & Kuehr, Ruediger & Khetriwal, Deepali. (2018). Material Flows of the Home Appliance Industry - CECED. http://www.materialflows.eu/

To support the transition to a circular economy, Government should implement the objectives set out in the Resources and Waste Strategy for England[3] to maximise the value of resource use whilst minimising waste and improving the environmental performance of all operators involved in the life cycle of products, by promoting the waste hierarchy.

The environmental impact of a product throughout its lifecycle should be taken into consideration during the product design and development process. Decisions made in the design stages greatly influence what happens to a product during its use and at end of life. Electronics are commonly designed to prevent repair and to encourage redundancy to increase sales. Product rules and standards should be altered to drive change and encourage design for durability (keeping materials in service for longer), utility (using products more extensively), repairability and recyclability. This should be at least as good as other major systems, such as the Japanese 'frontrunner' scheme or the EU's Ecodesign Directive. It should incorporate the 'right to repair', including mandating that spare parts are made available for repair, along with adequate repair instructions.

The costs to the environment should be accurately reflected in the costs to the consumer. This would impact the desire and demand for repair. A VAT reduction or removal on repairs could be used to help incentivise this, as has been the case in Sweden.

A well-designed extended producer responsibility (EPR) system for waste electronic and electrical equipment (WEEE) is key to facilitating the move towards a circular economy. The current EPR system for WEEE is based on 'collective producer responsibility', where producers finance the cost of collection and treatment based on their market share in specified equipment categories. Producers do not bear the costs relating specifically to their own products as they would in an individual producer responsibility (IPR) scheme[4]. The current system focusses on collection and recycling rather than considering environmental performance. Producers are not incentivised to improve the life, dismantlability or recyclability of products as costs are applied based on tonnes of waste, regardless of environmental impact. Regulations should be extended beyond collection, for example through smarter EPR or IPR, to incorporate wider circular economy principles such as keeping products in use for longer. A modulated fee system, where a fee structure is used to incentivise design that reduces the environmental and resource use impacts of equipment throughout its lifecycle, should be developed in consultation with the full supply chain. A modulated fee system provides a flexible and sophisticated mechanism to drive change.

Smarter EPR, designed with a modulated fee system where longevity, repairability and recyclability are incentivised will support the transition to a low carbon, more circular economy for electronic goods.

Alternative models such as service-based or lease systems can support the shift to a circular economy. For product lease systems, the consumer usually pays for continuous access to a product over an agreed period of time. The manufacturer typically retains ownership of the product and is responsible for delivery, maintenance and takeback. This encourages reuse, repair and design for longer life. Products are often recirculated which can reduce premature disposal. Circular models such as asset management of IT and healthcare services have been proven business to business where there is a collaboration between the manufacturer

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765914/resources-waste-strategy-de

[4] Calliafas, P, Bates, MP, Griffiths, G, Harding, A, Hawkes, A, Holloway, L, Keal, L, Kuss-Tenzer, C, Maguire, T, McIntyre, K & Taylor, E 2012, Waste Electrical and Electronic Equipment (WEEE) regulations: individual producer responsibility (IPR) in a UK context. Department for Business, Innovation and Skills.

and the business user. In some areas such as print services and IT managed services this is becoming the norm. Although these models have proven more difficult to implement on a business to consumer level in some instances, there are cases where this is working effectively including broadband equipment and TV boxes. Other examples where such models have been successfully implemented, and can be used to learn from, include gas cylinders, both for carbon dioxide for home fizzy drinks and butane for heating, and printer cartridges.

Domestic infrastructure should be supported to facilitate the efficient and effective recovery of valuable components and materials. Encouraging infrastructure on a distributed basis in cities or by regional centres can reduce the requirement for reverse logistics which can be significant in some circular economy models.

Investment in appropriate research and development and scale-up support for circular product design and recycling processes and technologies, supported by effective standards, will facilitate the transition to a circular economy.

What is the environmental and human health risk from e-waste? How significant is it and who is most at risk?

Electronics, like many advanced material systems, utilise specialist chemistries and materials that are often toxic but are used in relatively small quantities on the level of individual devices. The principal environmental and social challenges arise during primary material production, manufacturing and disposal – where the concentrations of these materials and substances are higher.

Mining, crushing and grinding of ore to extract the required minerals has a significant and lasting impact on ecosystems and local communities. This process is energy intensive and requires significant land management. The extraction of raw materials also presents risks associated with modern slavery, child labour and the funding of conflict. A clear example of this is the extraction of cobalt in the Democratic Republic of Congo (currently globally the main source of this important metal for batteries and other devices).

In the UK, strict controls and standards are in place for the safe handling of WEEE to reduce the risk to human health and the environment. The key risk in the UK is the loss of critical materials and other resources that cannot be recovered once they are placed in the residual waste. Materials are deemed ‘critical’ when they have a significant economic importance, are considered a supply risk and are not easy to substitute.

A risk of growing concern is the number of fires in the WEEE management chain, often as a result of damaged batteries, in particular lithium-ion batteries. The disposal of WEEE in household residual waste extends this issue to the wider resources and waste sector where fires have occurred at transfer stations and in collection vehicles.

The major risks to human health and the environment arise through informal recycling. Despite a number of global and regional initiatives, shipments of WEEE to developing countries continue unabated and result in significant environmental and health impacts. Improper collection, crude dismantling, material recovery and final disposal can result in the release of hazardous substances and significant impacts to workers, communities and the environment. Contaminants in WEEE are released in a variety of highly heterogeneous mixtures. Depending on the nature of the handling and processing, the contaminants can take a number of forms including particulates, gas, vapours, aerosols, solid residues, liquids (spent acid or wastewater) or semi-liquids (sludge from leaching solutions).

Commonly generated contaminants that cause concern include:

- Heavy metals such as lead, cadmium, mercury and nickel
- Persistent and bioaccumulative organic substances such as brominated flame retardants – often used in the plastic parts of electrical and electronic equipment (EEE)
- Polychlorinated biphenyls and polychlorinated dibenzodioxins released during processing such as crushing, shredding and burning
- Other persistent organic pollutants (POPs)
- Acids and cyanides emitted by chemicals such as the acids from batteries

Agbogbloshie in Accra, Ghana is notorious for crude WEEE recycling activities[5] and is the second largest WEEE processing area in West Africa. Exposure to the hazardous components of WEEE affects not only the workers but the local communities. Exposure is most likely to arise through inhalation, ingestion and dermal contact but can also occur through contact with contaminated soil, water or food sources and children are particularly at risk. Occupational injuries also pose a significant risk for workers and there is very limited use of personal protective equipment.

How can secondary markets for electrical goods be improved? What incentives are required to implement these markets?

Collaboration of the entire value chain will be required to redesign products for longevity and enable greater adherence to the waste hierarchy; reusing products and parts, enabling repair, improving recyclability, and recovering key materials.

Collection methods must be optimised to encourage both use by the consumer and to preserve the quality of products and their components. Small electronics are often stored by the consumer rather than returned for reuse, repair or recycling. Two major barriers prevent the return of small electrical goods: the ease of disposal in the residual waste and concerns surrounding personal data. Simple and accessible collection is required for small electronics coupled with clear and consistent communications. Information should be provided on what to do with small electronics, the importance of doing so and advice about data cleansing and safety.

For large WEEE, there is already a significant reuse market and recyclers do reuse at a significant scale. This is particularly true for large household appliances and IT. These work best with well-designed takeback schemes to ensure preservation of quality either through the supplier (as mentioned previously in lease models such as IT management) or via the retailer.

The social sector has a substantial demand for quality second-hand products, but collection methods must preserve quality to enable this reuse.

Measures that could be used to incentivise secondary markets include:

- longer, transferrable guarantees and recognised standards for safety testing of second-hand equipment
- reduced VAT on repairs

[5] Bates, M & Osibanjo, O 2019, Management of Electronic Waste in Africa. in GH Eduljee & RM Harrison (eds), Electronic Waste Management. 2 edn, Royal Society of Chemistry, pp. 137-165. https://doi.org/10.1039/9781788018784-00137

- recycled content tax
- long term security in the supply of good quality material
- improved coherence between chemicals, products and waste standards and legislation

More and better data is required to understand the extent to which products are entering the secondary market and to better understand material flows.

Why does recovering materials from electronic waste pose a significant challenge? What support is required to facilitate the adoption of recovery technologies?

Electronic waste is made up of a mix of different product types. Each product is complex and contains a mix of different materials. The compositional complexity of electronic waste causes a significant challenge, but there are steps and actions that can be implemented to facilitate material recovery.

For plastic, barriers to the shift towards a circular economy include fragmented value chains, the negative perception of recycled material by the end-user, quality and standards as well as price and demand. Currently recycled plastic, for example polypropylene, is more expensive than virgin material which will be exacerbated by the current decrease in oil price.

For metals, there is potential to be almost completely circular, however this can only be achieved if high quality material is collected. Small WEEE contains valuable materials, however it is often disposed of in the residual waste. Local authority kerbside WEEE collections are not widespread, requiring the householder to take the item to a household waste recycling centre or to collection points in shops. Large appliance collection through local authority bulky waste or as part of a new purchase often results in the item being put outside and subject to weather and damage thus reducing the options for reuse either as a whole appliance or as components. It is also often charged to the consumer, which can incentivise fly-tipping.

A significant barrier to recovering materials from electronic waste is due to the lack of design for dismantling – electronics are often intended to become obsolete, encouraging the user to buy again. They are often not designed to be taken apart, repaired, or upgraded, with manufacturers often assembling devices to prevent this actively. The materials are therefore difficult to access for high quality recovery.

Treatment of WEEE can vary depending on the type of WEEE and the technology used. Large-scale shredding technologies are widely used as well as manual or automated disassembly processes. Shredding processes break down the WEEE into small pieces which are then separated and sorted for recycling. Although some materials are recovered, yields can be low and critical raw materials are often lost from the system.

Critical raw materials have high economic importance and risk associated with their supply. Not only is the demand for electronics increasing but the same materials are required for the transition to renewable energy. Indium (used in touchscreens) is used for LEDs and photovoltaic cells, neodymium (used in microphones) is required for wind turbines, and lithium-ion batteries that contain cobalt are used for electric vehicles. This increased demand and competition for critical raw materials increases the supply risk and therefore the need to preserve and recover these materials as effectively as possible.

Whilst technologies do exist to recover most of the commercially valuable materials contained in electronics, these have not reached scale on a UK domestic basis. Doing so

would create high-value material streams and reduce the risk of material supply and environmental degradation, as well as provide a significant reduction in carbon emissions. Long transport distances of materials (notably critical raw materials), components, parts and products result in significant emissions of CO_2. For example, lithium is mined in South America, transported to China to be manufactured into batteries and then subsequently transported to Europe to be put into electric vehicles. The use of material that has been recycled locally, in place of raw materials, therefore significantly reduces the carbon impact of the final product. Furthermore, the reuse and repair of products, parts and components, in particular those that have high levels of embodied carbon, such as chips and circuit boards, can significantly reduce carbon emissions and support the transition to a more resource efficient and low carbon economy.

The presence of historical chemicals that have since been found to pose a risk to human health and the environment pose a challenge to the recovery of materials from electronic waste. Identification of the presence of these chemicals is important to ensure the WEEE is treated correctly and safely, but identifying the absence of these chemicals is also important to ensure material is not lost unnecessarily.

Electronics often contain sensitive data and the surest way to prevent disclosure is by destruction. Concerns around data eradication lead companies and consumers to destroy equipment that could be reused or recycled. Clear messaging should be developed with industry, to communicate how data can be removed successfully and securely with confidence. Hard disk drives and solid-state storage devices are regularly removed and destroyed to protect data. The University of Birmingham, as a partner of SUSMAGPRO[6] (Sustainable Recovery, Reprocessing and Reuse of Rare Earth Magnets in a European Circular Economy) is developing a pilot that will enable recycling of the metals contained within the magnets in these storage devices. [7]

Market stimulus through fiscal measures could go some way to facilitate the recovery of materials. Electronics are often too inexpensive and do not adequately reflect the environmental and social impacts of production. The UK consumer does not currently pay the true cost of the electronics they purchase. Electronic goods are likely to be disposed of prematurely because they lack perceived value even though they may remain functional – mobile phones, tablets, computers, game stations and TVs are now as much a subject of fashion as clothing. Externalities such as resource depletion, carbon emissions and the environmental and social burdens of production are not reflected in the price consumers pay. Were this to be otherwise, the cost of electronics would likely be such that leasing and service-based models would become far more appealing.

Incentivising the use of recycled content or a disincentive for using virgin material could be used to facilitate the adoption of recovery technologies.

In France, a collaborative approach involving all players has led to an increase in capture rate. The national level discussion body involving the collective schemes, the Government and recyclers federation discus and agree improvements two to three times a year. Learning should be taken from other good practices globally and ideally these should be merged to form a consistent approach.

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[6] https://www.susmagpro.eu/

[7] https://www.birmingham.ac.uk/news/latest/2019/08/Rare-earth-metal-recycling-pilot-project-launched-at-University-of-Birmingham.aspx

UK's Electronic Waste Sector

Are UK Waste Electrical and Electronic Equipment (WEEE) collection targets achievable? What challenges do UK producer compliance schemes and WEEE reprocessors face in meeting the collection targets?

- Targets should go further than the collection of WEEE and take into account the full lifecycle and environmental impacts.
- More and better data is required for both EEE and WEEE across the full value chain.
- Collaboration between different actors in the chain involved in the collection of WEEE is required. UK producer compliance schemes and WEEE reprocessors often do not control the collection.
- Small WEEE poses a challenge for collection – householders often keep hold of these items or dispose of them in the residual waste stream. More convenient, easily accessible options are required for smaller items as well as a clear and consistent communications campaign.

What causes fraud in the UK's e-waste system? How can this be addressed?

Free riding, whereby sellers operate through online marketplaces and do not comply with the WEEE regulations, causes a significant issue in the UK's e-waste system. These online marketplaces and fulfilment houses should be in the scope of an extended producer responsibility scheme and have the same obligations as producers. This is in line with the Government's commitment in the Resources and Waste Strategy to 'making sure that online sellers with an internet only presence are fully meeting their obligations'.

Full net cost recovery should be used to cover compliance monitoring and enforcement to ensure transparency, credibility and effectiveness of the system and reduce the risk of free riders.

What action can the UK Government take to prevent to the illegal export of e-waste to the developing world?

More and better data is required to enable more effective/smarter regulation and more focussed targeting and enforcement. Clearer customs differentiation between waste and non-waste, new and used electronics is required. We must ensure that products are valued properly in the UK and develop better markets for secondary material reuse and recycling.

It is important to note that end demand plays a significant role in driving illegal exports. For example, in Africa, second-hand products from the UK are actively sought after. The standard of repair skills is often high, and the perception is that second-hand equipment from the UK is better quality than new products made specifically for the African market. Individuals often travel to the UK and purchase second-hand products to send back without differentiating between tested (that would be legal to export) and untested (illegal). Operators in the UK have suggested that they have been asked for untested items for reuse and the occurrence of this question being asked suggests that this practice is taking place.

Illegal trade is often very informal, for example filling a hired container with lower priced items from car boot sales and online resale sites and shipping it abroad as personal possessions. This makes it difficult to regulate. It would be useful to raise awareness in the recipient communities through businesses that this trade is illegal.

What proposals does the UK Government need to consider as part of its consultation on WEEE?

Proposals, principles and learning the UK Government should consider include:

- A smart EPR (or IPR) framework that incorporates a modulated fee system that extends beyond collection to encourage and incentivise adoption of circular economy principles. This should include an explicit key objective of reduction to ensure alignment with the waste hierarchy, prioritising preventative measures over end of pipe approaches.
- Modulated fees to incentivise change and encourage producers to make more sustainable decisions through a more flexible and sophisticated mechanism, reflecting the rapidly changing nature of WEEE. The modulated fee system should be designed to incentivise beyond a target being met.
- Draw on experience and relevant learning from packaging EPR and international experiences to inform decisions and foster alignment where appropriate.
- Incentivise more sustainable product design that incorporates life cycle thinking, to encourage reuse, repair, remanufacture, product longevity and design for dismantling, extractability and recycling.
- Encourage simplicity, resource efficiency and reduction of material types e.g. reduced polymer types and where possible use polymers with high recycling rates.
- Full net cost recovery should be used to cover compliance monitoring and enforcement to ensure transparency, credibility and effectiveness of the system and reduce the risk of free riders.
- Fair allocation of funding across the full supply chain including communications and investment in the necessary collection services.
- Greater consumer engagement and clearer information and labelling to help households make better environmental decisions and prevent hoarding, increasing the quantity and quality of WEEE available for collection.
- Ensure regular reviews are undertaken on the effective implementation of the UK's policy on WEEE EPR to ensure that the intended aims are being met. This review process should be used as an opportunity to identify options for further evolution and take into account developments in infrastructure, product identification, policy development and EEE and WEEE composition.
- Drive change in product standards incorporating the 'right to repair', define requirements on the ease of disassembly and mandating that spare parts and adequate instructions are made available.
- Foster alternative and new business models that promote circular economy principles such as leasing or goods-as-a-service models.
- High quality data for EEE and WEEE.
- Collaboration and involvement from stakeholders across the full value chain.
- Full supply chain consultation, based on life cycle analysis, to reduce the risk of unintended consequences.
- A reformed system should be UK wide and be aligned with the ambitions and policy frameworks of each of the four nations.
- Be at least as good as other major systems and standards, such as the Japanese 'frontrunner' scheme or the EU's ecodesign system.

Is UK public awareness of e-waste recycling satisfactory? If not, how can it be improved?

No, public awareness of e-waste recycling is not satisfactory. Consumer engagement and awareness is required to increase the availability of products and material for harvesting and to reduce fly-tipping. For large appliances, consumers need to be aware of what to do with the item once they no longer want it and be able to make the right choice to preserve quality and protect the environment. Small e-waste collection requires improvement coupled with additional communications campaigns to encourage take up and success.

Consumers have a critical role to play in achieving the uplift in quantity and quality of WEEE that is recovered. Widespread communications, for example on national TV or via social media, could be used to ensure e-waste recycling is prevalent in the public's mindset and the option to 'do the right thing' is encouraged and accessible. Consumer confidence is essential, particularly due to the sensitive nature of data stored on personal electronic devices. Consumer campaigns should therefore include clear and consistent messages about data wiping and safety.

Changing the behaviour of the consumer can have a dramatic impact on the success of schemes and measures. Lessons can be learned from the plastics debate, both from the positive role of community wide engagement and the risk of unintended consequences. Consumers must be equipped with the information required to make informed choices and the same, accessible recycling opportunities should be available to everyone.