CLEVER – Closed Loop Emotionally Valuable E-waste Recovery

Summary

The rapid turnover in consumer electronics, fuelled by increased consumption, has resulted in negative global environmental and social consequences. These appliances are typically disposed of into UK landfills or to developing countries, incinerated, or otherwise 'lost' - very few are recycled. As a result, the metals they contain are not effectively recovered and new materials must be extracted to produce more goods. Reportedly more than half of all UK households are dissatisfied with how long small household appliances last and think they should last longer, yet, while several strategies to extend product lifespans have been developed, they are under-utilized within the consumer electronics market. Materials scarcity, particularly of non-renewable, finite resources, is a global concern and one that UK consumers and manufacturers cannot ignore. To use these resources more efficiently and reduce mounting electronic waste (e-waste), consumers must be encouraged to retain their devices for longer and return them at the end of their life (or before).

To assist in a transition from the current 'throw-away' society towards a new model we will develop a function-oriented business model, called a Product Service System, which shifts the focus from designing (and selling) physical products only, to designing (and selling) a system of products and services incorporating both service and ownership, which are jointly capable of fulfilling consumer needs. In this system component parts with 'low-emotional value', but requiring regular technical upgrade (such as the printed circuit board or flexible circuits) will be owned by manufacturers and leased to customers, and potentially "high-emotional value" components (such as the outer casing) are owned and valued by the customer, so that they become products that are kept for long periods of time. In this project these parts are termed the 'skin' - the outer casing, or the part that the user interacts with directly; the 'skeleton' - the critical support components inside the device; and the 'organs' - the high-tech electronics that deliver the function and which need to be the most up-to-date parts of the device.

To encourage greater emotional attachment to products, new materials which 'age gracefully' will be developed and consumer responses to these materials explored. To recover component parts quickly and efficiently for recycling and metals recovery, new skeleton materials based on biopolymers will be designed and produced. The most important characteristic of these materials is that they will be stable and robust while in use, but can be triggered to decompose when the device is to be taken apart for recycling. Such triggered disassembly of the innards of the device will facilitate the recovery of the valuable metal containing electronic 'organs' so that these can be efficiently recycled and retained in the closed loop of electronics manufacture. The project will also address the efficient recovery and recycling of some of the most valuable metals contained in electronic devices.

At each stage of development, a social and environmental analysis of the proposed PSS and materials will be undertaken to identify any negative impacts. Together these materials and the new product-service system will enable greater resource efficiency and contribute to reducing greenhouse gas emissions (which contribute to climate change) and reducing annual environmental costs of waste being sent to landfill (estimated at £211m), while enabling efficient recovery of metals, thus maximizing use of resources, reducing costs, and improving UK resilience by reducing reliance on imports.

Keeping electronic devices in a closed loop also means they are less likely to become part of the e-waste exported (sometimes illegally) to developing countries, where people may risk their lives to recover the valuable metals by burning, or smelting, processes that may release dioxins, or use mercury.

Objectives

In this project we propose combining social science and design approaches with materials development and materials engineering to enable the development of consumer electronic devices that invoke an emotional attachment from the customer, resulting in a desire to retain the product (changing the product lifetime), which will be facilitated by returning the product to the manufacturer for replacement of the hardware, and thus provide opportunities for recycling and retaining the valuable metals in the manufacturing loop.

Specifically we will:

1. Engineer composite 'heirloom' materials for the outer device case coverings, which provide properties akin to those of materials considered to improve with age and elucidate the properties of these novel materials;
2. Develop plasticized biopolymer based support materials for internal device parts that are amenable to triggered degradation (e.g. by enzymes) allowing disintegration on demand, thus releasing metal components as a concentrated mass;
3. Demonstrate recovery and separation of valuable metals from the pre-concentrated mass using a differential dissolution, extraction and electrowinning strategy;
4. Investigate how to extend product life through creating emotional value and develop a Product Service System that differentiates ownership and service;
5. Explore how citizens understand their relationship to products, waste and recovered resources;
6. Consider socio-political and economic impacts of the proposed Product Service System and conduct a Social Life Cycle Assessment; and
7. Use (Environmental) Life Cycle Assessment to enable comparison of impacts of changes in manufacturing processes and product components.

Workpackages

The project is to be delivered via 6 defined workpackages, Fig 1. We will exploit all opportunities for information dissemination and impact provided by the CORE Network[1] including: the Monthly Signpost e-newsletter; presence on the TSB Connect/KTN website; CORE Cross-cutting Themes and CORE Innovative Outreach. The CORE Network provides links to other projects in Resource Efficiency (RE) (inreach) and externally (outreach), but, very importantly for this project, it also offers a visible presence for coherent presentation of results from all RE projects – we see this as core to realising impact, Fig 1.

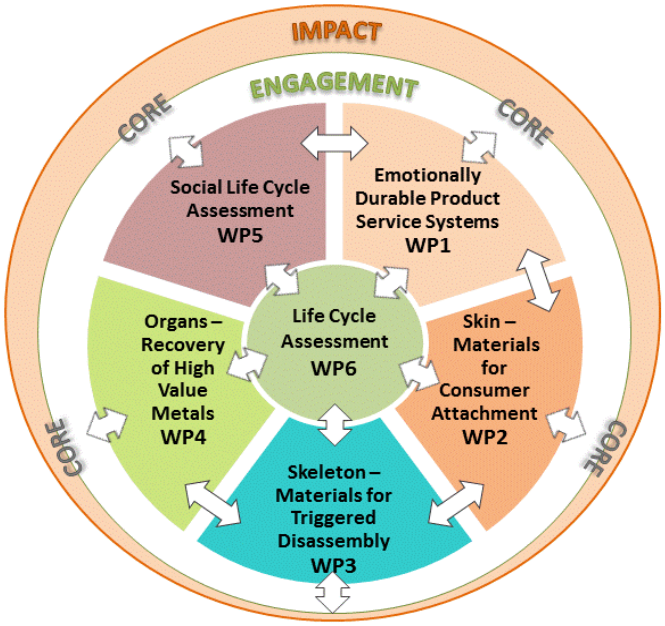

Fig 1. The relationship between WPs, engagement with the public and delivered impact. This project includes inputs from consumers with integrated WPs focussing on design and social aspects to ensure that engineering solutions are appropriate to the problem and are not frustrated at implementation stage. Environmental considerations are intrinsic to the project and addressed via detailed LCA.

[1] CORE - Creative Outreach for Resource Efficiency - is the network created project is to support the delivery of a vibrant and creative outreach programme to maximise public and user engagement in resource efficiency.