PC Reuse at the University of Edinburgh: A Qualitative Evaluation of its Delivery Model

by
Dr. Katharina Kaesehage
Hasan Muslemani
Professor Kenneth Amaeshi
Georgina Jamieson

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1. Introduction

The University of Edinburgh has enabled the internal and external reuse of Personal Computers (PCs) and other small Information Technology (IT) equipment. The purpose of this report is to identify the delivery model behind this current internal PC reuse process and evaluate if and how this process could be improved and expanded. This report will discuss the literatures on reusing products while maintaining their highest possible value as well as the Circular Economy. It will also focus specifically on the scarce knowledge on the reuse of PCs and IT equipment. Following this, the current process of reusing PCs at the University of Edinburgh and its achievements to date will be presented. The report aims to advance the understanding around the reuse of PC and IT equipment by proposing a reuse model for best practice from the perspective of large-scale consumers.

2. Developments to Date

The first efforts of reusing PCs at the University of Edinburgh were implemented by the Department for Social Responsibility & Sustainability in collaboration with the University's Information Services, Waste and Recycling (based in Estates) and Records Management. This initiative was motivated by the desire to reduce the University's waste. It was found that the University disposes ca. 4,000 PCs per year, of which an estimated 20-25% are reusable through either extending the PC's usage internally - saving ca. £250,000 through reducing purchases of new PCs - or finding re-use opportunities externally (Hart 2016). A pilot study to test this approach was subsequently implemented from December 2014 to December 2015 with funding support from Zero Waste Scotland to test this further from January to June 2016. Since then, the University has continued to implement this process.

3. The Circular Economy

The risks caused by climate change to society present one of the most pressing challenges to humanity (IPCC, 2013). Climate change could cost the world economy up to 20% of global Gross Domestic Product (GDP) each year (Stern Review, 2006) and jeopardise social and economic prosperity (Jackson, 2009). Caused primarily by fossil-fuel burning and other anthropogenic activities, climate change is linked to the current economic system whereby companies and people produce and consume goods in order to maximise their own utility (Simon, 1959; Harris, 2001). However, the main pitfall of this system is that individuals often believe that their responsibility for handling their products ends once this utility has been attained (Rau, 2013). The linear model of production and consumption - take, make, consume, discard – has come under scrutiny (Jackson, 2009) because individuals are unable to meet 'the needs of the present without compromising the ability of future generations to meet their needs' (WCED, 1987, p. 1). Consequently, many ideas are developed and discussed on how society could transition to a new economy to enable more sustainable production and consumption (cf. Jackson, 2009; Seyfang, 2009; Heinberg, 2011).

One of those ideas is the 'circular economy'. The circular economy is an economic model which outlines a way in which societies can diverge from the current linear model of production and consumption by decoupling economic growth from finite resource consumption (EMA, 2014). It proposes an economy that is 'restorative and regenerative by design, and which aims to keep products, components and materials at their highest utility and value at all times, distinguishing between technical and biological cycles' (EMA, 2016, p.18). This integrative perspective suggests that a product's production, use and end-of-life are connected to each other as a closed-loop system of the economy to maintain their highest utility and value throughout the manufacturing, usage and re-manufacturing process (EMA, 2016; George et al., 2015). The three key principles are displayed in Figure 1.

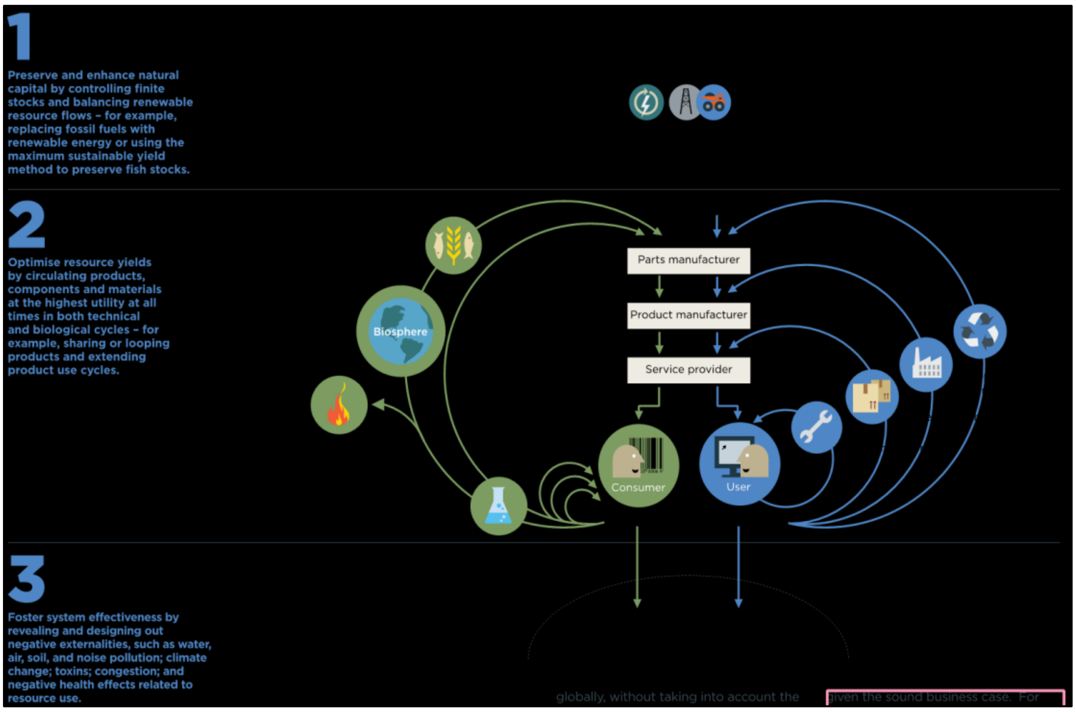


Figure 1. Circular economy structure (EMA 2016).

Projections for the implementation of circular economy approaches in Europe are promising. It is estimated that, after 2020, costs of up to $630 billion could be saved annually across Europe if circular economies were implemented in sectors of medium-lived complex products alone (EMA, 2016) – 'products that are in use for a short enough timeframe that they are subject to frequent technological innovation, but long enough that they are not subject to one-off consumption' containing multiple parts suitable for disassembly such as consumer electronics (EMA 2013, p. 37). The long-term benefit would be that prices for raw materials as well as demand-driven volatility would decrease. In Europe, a shift towards circular economies in the industrial sectors mobility, food and built environment could increase resource productivity by up to 3% annually (EMA, 2016). Other benefits would materialise in an increase in GDP and jobs creation with a simultaneous reduction in carbon emissions (Quariguasi-Frota-Neto & Bloemhof, 2012).

4. Implementation of the Circular Economy

Even though the concept of the circular economy has been highly celebrated, its practical implementation remains considerably low (EMA, 2016). This has been attributed to certain barriers such as the need for complex information sharing and feedback-rich systems (EMA, 2016) as well as the active participation of actors across society (Ghisellini et al., 2016). Preston (2012) also highlights that many businesses and public-sector organisations still do not understand how a circular economy is applied in practice. Rather than providing a strict definition of what a circular economy is, the EMA (2016) depicts the concept as an approach with specific characteristics that 'preserves and enhances natural capital, optimises resource yields and minimises system risks by managing finite stocks and renewable flows' (EMA, 2016).

This might, however, be one of the pitfalls of the circular economy. Murray et al. (2015) argue that that the notion of the circular economy merely provides general guidelines and systematic thinking for (re)-structuring the ways in which products are manufactured, used and reused. Individual organisations then need to understand how specific implementations within their business context are undertaken (Murray et al., 2015). The academic literature only provides few suggestions on what circular economy business models should look like. Many studies categorise circular economy approaches according to the type of implementers instead of their business models i.e. individual organisations and businesses, industrial parks and industry group and governmental structures such as cities, regions and states (Ruiz et al., 2015; Ghisellini et al., 2016). The Ellen MacArthur Foundation (EMF) suggests that an absence of clear re-use models, such as those for mobile devices, is due to a diverse range of products which are highly varied and continuously evolving (EMF, 2016). They therefore propose a number of individual interventions instead of an entire business model to allow individual companies and organizations to implement the circular economy approach. These interventions are activities in the following areas: 1) software led longevity, 2) better reuse, 3) minor modularity, 4) cloud offloading, 5) parts harvesting and remanufacturing, or 6) do-it-yourself repair (EMF, 2016.).

5. Information Technology, PCs and the Circular Economy

In 2009, over 50 million tonnes of electronic waste was disposed worldwide (Jiang et al., 2012), however, most of this waste was simply exported to developing countries (STEP, 2009). Only a few studies have investigated the potential and related activities for PC reuse. Electronic equipment can be an important source of secondary raw material once it has reached its perceived end-of-life (Sarkis and Zhu, 2008). Making use of the opportunities of unwanted electronic devices is especially important because the time period during which a device is used, called the performance cycle, is decreasing while the time a device could be used, the life cycle, is increasing (Rau, 2013) (Fig. 2).

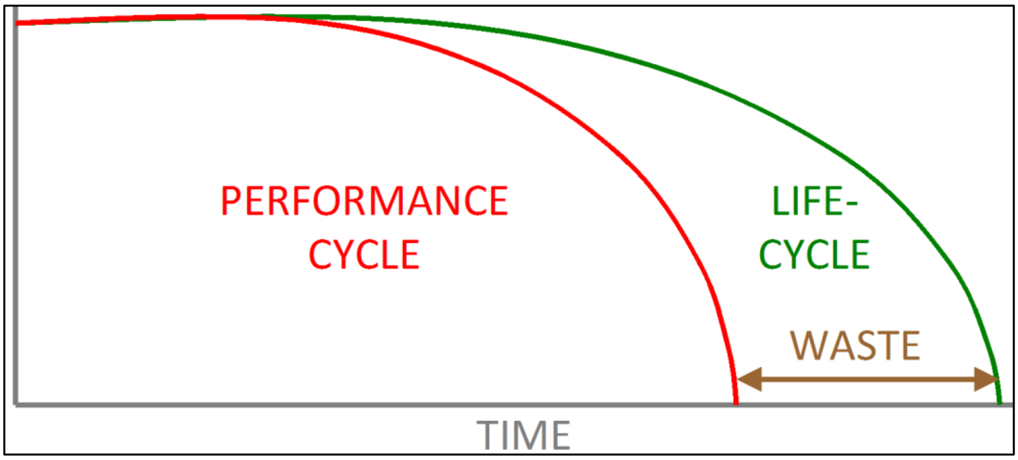


Figure 2. Performance Cycle vs. Life Cycle as adapted from Rau (2013).

The lost usage between performance cycle and life cycle is because of a culture in which people aim for more fashionable and modern products (Rau, 2013). The average lifespan of a PC has decreased from 8 years in 1990 to 2 years in 2010 (Babbitt et al., 2009). The main steps of electronic waste are detailed in Figure 3 as proposed by the World Bank (2012). The figure shows that electrical waste runs through four main stages: generation, collection, treatment and output. In the last stage – output – there are three directions into which electrical waste can go after its perceived end-of-life: landfill, secondary raw materials or reuse.

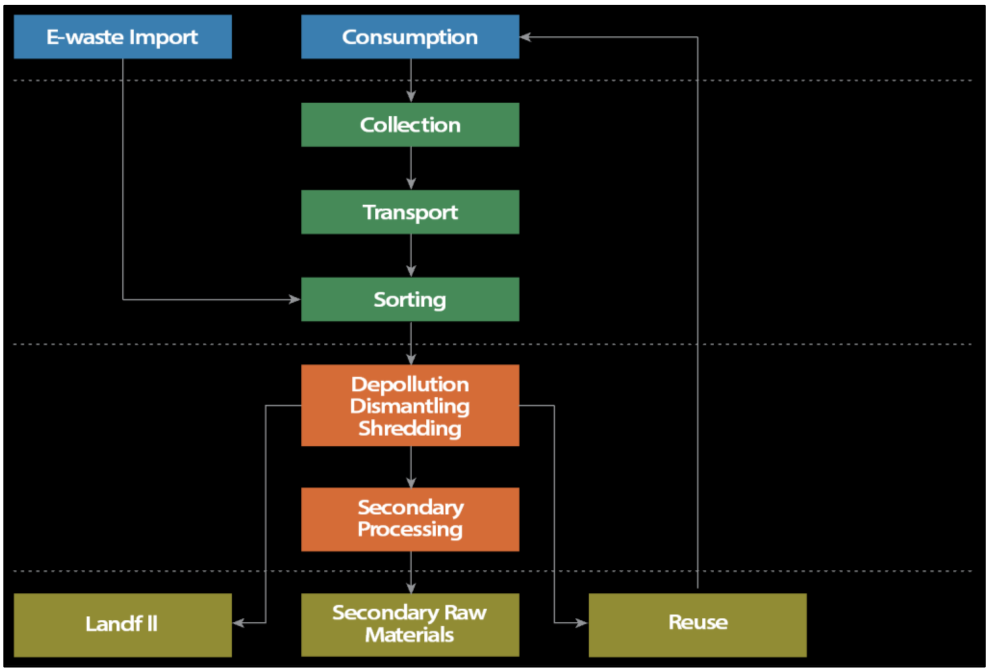


Figure 3. Electrical waste cycle (World Bank, 2012).

Hazen et al. (2017) believe that peoples' perception towards remanufactured products determines if people are willing to switch to re-manufactured products. Nevertheless, the reuse market for electronic waste is promising from both an economic and environmental perspective. IT parts and components, according to Benton et al. (2015), are thought to be worth £10 million a year in the UK. In the USA, the total value of Apple devices sold on eBay was around $2billion in 2013 (Benton et al. 2015). Additionally, PC reuse is estimated to create around 300 new jobs yearly for every 10,000 tonnes of material disposed (Unido, 2009). The environmental benefits of simply extending the usage of a smart phone by one year, for example, are also telling: it reduces its CO_2 impact by 31% (Benton et al., 2015).

However promising, many studies have suggested that the problem of reusing PCs is that it remains considerably labour-intensive. Before 2005, PCs were easier to be re-manufactured due to their simplicity, today the design of PCs is more complex due to smaller structures and other components as well as other factors such as the use of glue instead of screws (Wharton, 2016). It is thus more difficult to disassemble electronic products (Cooper, 2016). Additionally, electronic products for reuse are often missing spare parts once they reach the remanufacturing stage (Rreuse, 2012). Rreuse (2012) provides numerous suggestions on how the reuse market for PCs could be improved:

- Increased networks of accredited reuse centres: Reuse centres systematically collect, prepare and distribute old products. They are well established in many industries and often provide quality guarantee labels. Rreuse (2012) suggests that such centres should receive greater access to waste collection points of WEEE to build greater awareness and uptake of reuse in this industry.

- Set separate 'prepare-for-reuse' targets: Legally binding targets should be set in order to force producers to set up reuse opportunities from the design stage.

- Designing products that last: This should enable the production and consumption of products that can easily be reused.

- Economic Incentives: Rreuse (2012) suggests that taxes on reuse-related activities such as repair work should be decreased and/or special fees should be introduced for products that are more difficult to dismantle and reuse.

Many manufacturers have tried to tackle some of the challenges by designing products that are more compatible with a circular economy approach – this is crucial as 80% of the environmental footprint of products is locked in at the design stage (DEFRA, 2005). Case in point, Dell has prioritised recycling in the phases of its products' lifecycle for which it has won the 2014 'Design for Recycling Award'. Some of Dell's tablets and laptops were designed with recycling in mind and the products incorporated modularity in design, minimal usage of glue/adhesives, clear labelling of individual parts for identification, and appropriate disassembly guides. Other manufacturers – such as Samsung, Sony and Panasonic – also have programmes through which they retrieve old electronic devices for re-use (Wharton, 2016). Some retailers such as Best Buy, Amazon, and Staples have implemented take-back programmes (Wharton, 2016). Hewlett-Packard turns customers into users to enable Circular Economy products (McIntyre and Ortiz, 2016). Community and public-sector organizations also undertake take-back programmes and The University of Pennsylvania for instance collects old electronic devices through collection points (Wharton, 2016).

6. Electronic Waste and Legislation

The European Union regulates electrical and electronic equipment waste through a number of legislations, of which two of the most instrumental include:

1. The Waste Electrical and Electronic Equipment (WEEE) Directive, also called the 2012/19/EU Directive, provides collection schemes to enable consumers to return their WEEE free of charge. This aims to increase the recycling of WEEE and/or re-use. The Directive regulates the collection and recycling of products from the following ten categories of WEEE (HSE, 2017):
    - Large household appliances such as fridges and washing machines
    - Small household appliances such as vacuum cleaners
    - IT and telecommunications equipment such as PCs
    - Consumer equipment such as radios and televisions
    - Lighting equipment such as high intensity discharge lamps
    - Electrical and electronic tools such as drills and sewing machines
    - Electric toys
    - Medical devices such as cardiology equipment
    - Monitoring and control equipment such as smoke detectors
    - Automatic dispensers such as money dispensers

2. The Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment (RoHS Directive) (HSE, 2017). The RoHS recast Directive (2011/65/EU) requires heavy metals such as lead, mercury, cadmium, and hexavalent chromium and flame retardants to be substituted by safer alternatives. In December 2008, the European Commission proposed to revise the Directive (HSE, 2017).

7. Circular Economy and Higher Education Institutions

Reusing IT equipment is fairly novel not only amongst Higher Education Institutions, but amongst other organizations more generally. There are a number of universities that have put forward initiatives around the circular economy, nevertheless, these efforts remain mainly focused on the educational benefits for students as opposed to implementing the process itself by reusing products within the institutions. Some HEIs, such as University College London, have introduced the concept of circular economies as a topic for specific courses within their undergraduate and postgraduate degrees. Similarly, the University of Bradford offers a Master of Business Administration (MBA) in Circular Economy. The University of Bradford, along with others such as Kedge Business School and Cranfield University, have founded research centres and/or created research positions to investigate the role of the circular economy. They also work closely with businesses and public-sector organisations. Most of these universities participate in the Circular Economy 100 (CE100) – an international platform that facilitates learning and collaboration between businesses, Universities and public-sector organisations.

8. PC Reuse at the University of Edinburgh

In 2014, the University of Edinburgh's Department for Social Responsibility & Sustainability, Information Services, Waste and Recycling and Records Management identified that 20-25% of the University's annually-disposed PCs could be reused internally and externally. The University therefore implemented a pilot project which aimed at identifying and internally reusing desktop PCs and monitors to reduce the waste stream. A pilot study to test this approach was undertaken between December 2014 and December 2015 by the University's Department for Social Responsibility and Sustainability (SRS) with funding support by Zero Waste Scotland. It was found that, by extending the performance time of a PC and its monitor from four years to six years, around 190 $kgCO_2e$ of carbon emissions could be saved. Since then, the University has continued to implement this reuse and recycle process. While it is well understood that the University reuses its PCs, it remains unknown 1) how the process is delivered, how different stakeholders are interlinked in the delivery of this model and how some of the traditional barriers of IT reuse are overcome, and 2) how this project could be improved and expanded. The research questions are:

1. **What is the PC reuse delivery model at the University of Edinburgh and how were some of the traditional barriers of IT reuse overcome?**
2. **How can this model be improved and expanded?**

Building on the review of the current literature, the research and thus this report aims to advance the understanding around the reuse of PC and IT equipment by proposing a reuse model for best practice from the perspective of a large-scale consumers.

9. Methodology

As our research focuses on the stakeholders of the PC reuse project implemented at the University of Edinburgh, we undertook interviews with people that internally and externally process and/or recycle PCs. We chose to focus on these specific stakeholders to determine how the actual implementation of the PC reuse model functions and how the different stakeholders implement it. The interviews covered a list of topics which were common to all stakeholders. We also used purposive snowball sampling which allows stakeholders to be viewed in relation to each other whilst acknowledging that they operate in existing, complex social relations that influence their behaviour and knowledge (Law and Hassard, 2007; Dolwick, 2009). As such, and due to the social nature of the research, we deployed qualitative analytical methods. We stopped approaching additional stakeholders once our data were saturated and the additional observations were reflecting similar findings to earlier ones.

9.1. Participant Sampling

We used key informants to identify stakeholders who are impacted and/or would be impacted by the University's PC reuse process. Table 1 summarises the study's participants from across the current project in addition to other more general stakeholders. In total, 7 stakeholders took part in semi-structured interviews throughout our study (April 2017 to July 2017).

Company Type	Position
WEEE Contractor	Sales & Marketing Director
University of Edinburgh Waste & Recycling Department	Waste & Recycling Manager
University of Edinburgh Waste & Recycling Department	Former Waste & Recycling Manager
University of Edinburgh Information Services	Chief Information Officer
Department of Social Responsibility & Sustainability	Projects Coordinator
Department of Social Responsibility & Sustainability	Project Intern
Not-for-profit Agreed Partner	Enterprise Director

Table 1. List of stakeholders participating in this study.

9.2. Data Sources

We chose to use Eisenhardt's (1989, p. 547) concept of 'theory building' due to the limited number of research studies that explore the implementation of PC reuse processes. We used a range of data collection methods:

- *Open interviews* with key informants/individuals who work in the University's PC reuse project. They provided an overview on recent developments and suggested stakeholders who should be interviewed.
- *Indicative interviews with stakeholders* served to understand the delivery model behind this current internal PC reuse process. The stakeholders discussed if and how this process could be improved and expanded. The semi-structured interviews covered a list of topics which were common to all stakeholders (see appendix), and utilised open questions which allowed participants to address issues not necessarily raised by the interviewer (see Lapan et al., 2012).
- *An online questionnaire* complemented the information collected through interviews. The questionnaire gathered data and helped inform our understanding of the usage of the current PC reuse project by a broad group of employees within the University of Edinburgh. This provided an opportunity to detect how different employees experience working with the current process.

In total, we conducted 2 open interviews with key informants, 7 semi-structured interviews with stakeholders and an online questionnaire that yielded 12 responses from the Information Services team at the University of Edinburgh.

9.3. Data Coding and Analysis

We took an iterative approach to data analysis based on Gioia et al.'s (2013) analysis guide. We reviewed the date based on whether and how the PC reuse process could be improved and expanded. This initial stage identified significant themes which informed a coding frame. Using Nvivo, we formed 1st-order concepts. We then identified similarities and differences between the themes developing more specific 2nd-order themes and developed theory dimensions.

The coding involved an iterative process of going back and forth between themes, data and sub-themes. We then used the data gathered in the online survey to evaluate potential barriers and solutions of the re-use process. We then analysed the themes in reflection to our research questions and established interpretations.

10. Findings

In the following section, we present the business model for reusing and recycling PCs at the University of Edinburgh. We detail how the PCs are processed along the different stakeholders and graphically display their interaction. We also show how this delivery model could be improved and list the key enablers to overcome traditional barriers.

10.2. The PC Reuse and Recycle Delivery Model

Since the pilot study in 2015, the University of Edinburgh has institutionalised the process of reusing and recycling PCs. This process currently only considers PCs and monitors as well as some small IT equipment such as keyboards. Handling PCs that have reached the performance cycle for reuse means that the University considers the options of internal as well as external reuse. Guidance for categorisation of PCs has been based primarily on the PC's model and then on its age. More than 60% of our survey respondents also reported having made judgment on whether PCs can be re-used based on their overall condition, other specifications (e.g. amount of memory – RAM), and ease of upgradability i.e. the ease of adding more RAM or a larger/faster hard drive.

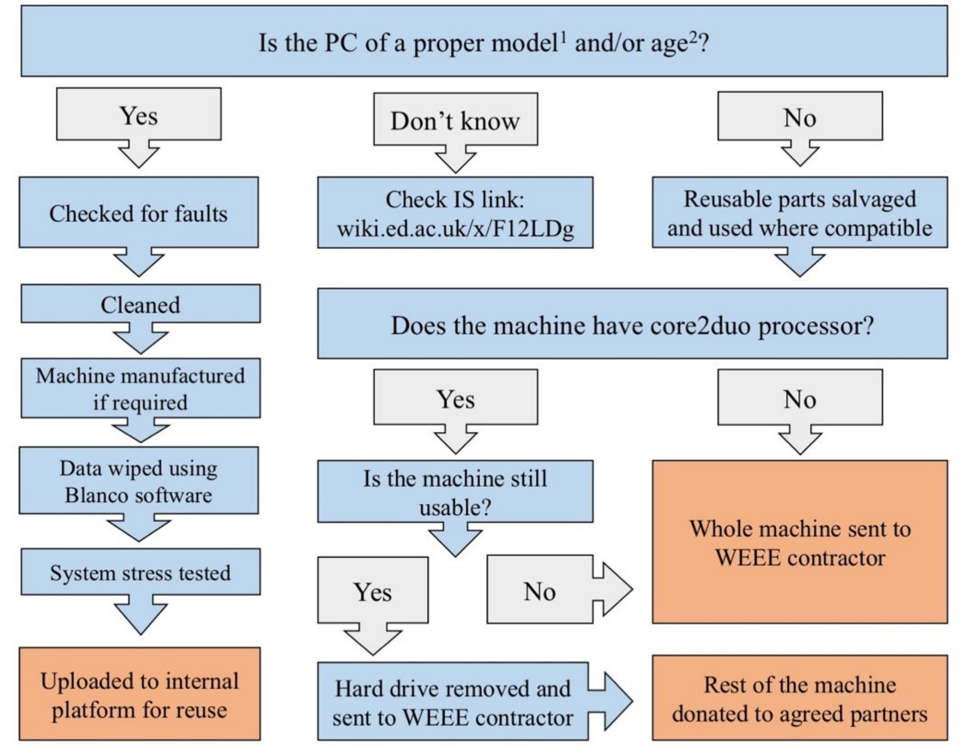
PCs of specific models[1] and that are **younger than 5 years** are made available by Computer Reps for personal reuse for staff and PhD students. These PCs are registered online to the platform 'Warp-it' and subsequently transported to the University's reuse distribution centre. Warp-it is a free[2] resource distribution tool run by the Department for Social Responsibility and Sustainability and through which members of staff and PhD students can advertise or claim unwanted items for free. Currently, there are over 500 members to the platform. Once a PC arrives at the reuse distribution centre, it is investigated, cleaned and hard-drives are securely wiped using Blanco - a high-standard data wiping software. The PC is upgraded and then advertised on Warp-it. Priority for internal reuse of the extracted hard drives is classified systematically – first according

[1] Reusable PC models include: HP EliteDesk 800 G1, HP Elite 8300, HP Elite 8200, HP8000 or Optiplex 7010, Optiplex 790, Optiplex 780. Desktop Services recommend having 8G worth of RAM to use the current University desktop.

[2] It is free to use for users, however the University of Edinburgh pays an institutional fee for this which is covered by the Waste Office

to the size of the drive and then according to its age.

The SRS department aims to improve the lifetime efficiency of PC and IT equipment reuse in terms of its contribution to carbon savings. SRS reports to have successfully reused around 20% of PCs that would have otherwise been recycled by the University's waste contractor. This research has found that Warp-it managers estimate that around 500 PCs are being reused on average on the platform per year and that they aim to increase this figure to 750-1000 PCs/year. Having identified this aim through this research, should allow the IT team to aim for this increase in reused PCs over the next 1-2 years. However, with demand for certain items and components forecasted to change with seasonality, it is also recommended that the University should dedicate or allocate new storage facilities to account for the increase in the supply of reusable PCs. To overcome this and other limitations, the internal PC reuse project is scheduled to be moving from the SRS department to the IS department as the latter has the physical capacity – in terms of storage and expert IT personnel – and a centralised system of communication that can oversee the appropriate management and expansion of the project. This research confirms that this is a strategic step for the University of Edinburgh.



[1] Qualifying models are listed in footnote 1.
[2] As a rule of thumb, PCs older than 5 years old are considered non-reusable.

Figure 4. An overview of the current PC re-use model at the University of Edinburgh.

In Figure 4, a flowchart is presented which shows an overview of the current PC re-use model. For PCs that are **between 5-8 years old**, reusable parts are salvaged and reused where compatible. If the PCs meet minimal requirements for reuse (e.g. a core2duo processor) and is still usable, the hard-drives are removed and sent for recycling through a waste contractor while the rest of the PC – or its 'shell' – is donated to local not-for-profit agreed partners. If the machine is not usable or is **older than 8 years**, the entire machine is recycled.

Since 2002, the University's licensed Waste Electrical and Electronic Equipment (WEEE) contractor has been CCL North. On a weekly basis, CCL North collects and recycles all electrical and electronic equipment including, but not limited to, lab equipment, centrifuges, fridges, freezers, microwaves, and televisions to recover raw materials. Between 2005 and 2010, IT equipment has been gradually included in CCL North's University-recycled equipment. CCL North meets the SEPA regulations and Health & Safety requirements and is paid an annual honorarium for their services. As far as data protection is concerned, where HDs are deemed to be highly sensitive (e.g. including child protection or sensitive data), they are physically destroyed on site. Designated University personnel occasionally accompany collections of hard drives with sensitive data to oversee the destruction process on CCL North premises.

Where HD-less PCs are reusable but do not conform to the internal reuse standards, they are donated to the charity Remade in Edinburgh. The University of Edinburgh has a formal partnership agreement with Remade whereby they collect, repair, and refurbish all equipment that cannot be reused on Warp-it. Through its reuse model, Remade aims to create a step-change in the way resources are reused locally – with a motto that emphasises the 'creation of goods to last and not to be disposed of'. Remade undertakes outreach repair workshops in other Higher Education Institutions around Edinburgh (e.g. Edinburgh Napier University and Heriot-Watt University) to raise awareness and help mitigate the environmental impacts of IT disposal and aid local authorities in meeting their reuse targets. Funded by Zero Waste Scotland, the Remakery has been shortlisted for other sources of funding to help replicate its model in other areas of the Lothians and Fife. Remade is environmentally-friendly and also exceptionally economically attractive as it substantially reduces the costs associated with the purchase of second-hand items and reselling them to the local community. Remade in Edinburgh, having acquired various storage facilities around Edinburgh, has the capacity to handle around a third (e.g. 800-1000) of total PCs being recycled by the University of Edinburgh per year.

In light of the roles and benefits of the project to its different stakeholders, the following section provides some propositions for improving the current model within the University of Edinburgh and assesses its transferability prospects to other HEI and non-HEI institutions.

10.2. Propositions for Improvements

Our research revealed two ways in which the current reuse delivery model could be improved: first, by targeting local re-users and second, by accounting for the full carbon footprint of the model. Both recommendations have been identified through this research study and will be disseminated to University stakeholders, who will decide when and how they can implement these recommendations.

The first suggested improvement was a recurring theme within the semi-structured interviews where concerns regarding the end-destination of the reused and recycled products were raised. The participants pointed out that most of the PCs and other items are sold to business vendors, through the WEEE contractor, who in turn sell the items outside Edinburgh for profit. While economic benefits are still occurring for the various stakeholders, the participants argued that the potential positive impacts of the business model might remain minimal at a local level. The participants questioned whether it might be possible to make more PCs and IT items accessible for free or a low cost to local people and community organisations. The University's current model (as shown earlier) demonstrates an attempt to tackle some of these criticisms by closely collaborating with Remade in Edinburgh. Remade, for example, refits the PC shells they receive with appropriate HD capacity or processor memory and sells the PCSs at affordable prices (circa. £70/PC) to members of the public. However, the participants suggested that the University should *directly* target some of the local communities, in particular students. This is especially relevant for undergraduate students who might not have the financial means to purchase brand new items and who are not eligible to claim warp-it-advertised items.

An identified percentage of the refurbished PCs that should be available on Warp-it could also be donated directly to students in need. This idea seems plausible as 20-40% of all IT equipment could benefit from the services offered by Warp-it. Refurbished PCs could be potentially returned from the WEEE contractor directly to the University for reuse or through Remade in Edinburgh for students to buy them back at discounted prices. Such a scheme would not, however, be instituted without having to tackle some challenges. These challenges might materialise in the transfer of equipment ownership, the establishment of a set of guidelines for reuse eligibility requirements and a clear and replicable framework to ensure the efficiency of the roles of all parties is maximised. Improving the current model will require transparency in partnership terms with stakeholders, clear direction and proper project management. The model would also benefit from allocating a designated person within each department to foresee the timely implementation and efficient reporting of the project's impact and outcomes. These will ensure the project moves from its initial stage to further raise awareness and engage all Schools and departments within the University. This would ultimately set an institutional example in the local application of a circular economy approach – one that helps HEIs cost-effectively reuse their equipment while saving the environment.

The second suggested improvement is to take full account of the carbon footprint throughout the model's delivery. The interview participants have frequently raised concerns over the model's potential to reduce the university's carbon footprint with regards to recycling and reusing PCs. They pointed out that the emissions associated with transportation to and from the waste contractor (based in Ayrshire), and from the contractor's premises to its vendors remain unaccounted for. This is especially relevant if items were shipped overseas.

Some of the participants also suggested that other IT items – such as laptops and mobile phones – should be incorporated in the reuse and recycle model. However, after having discussed this with the WEEE contractor and the University's IT department, we learned that PCs remain the easiest to refurbish at low and feasible costs. Laptops and/or phones are more labour intensive to recycle and would yield limited returns in financial and performance cycle extension terms. The literature consulted and reported in the review also supports this and shows that an expansion of the business model at the University of Edinburgh would require a close collaboration with IT manufacturers to allow for changes to the items at the design stage. Nevertheless, our research has shown that reusing and recycling PCs – although challenging – can work and that the University of Edinburgh is able to overcome some of the challenges that are normally encountered with applying circular economy approaches. We discuss this in the following section.

10.3. Enablers

Our study shows that this innovative business model to recycle and reuse PCs works due to the existence of three key enablers: first, a database serviced by an IT team, second, an IS department processing PCs, and third, partner organisations for recycling and reusing PCs.

1. *IT database serviced by an IT team:* A complete data base listing the University's PCs and IT items characteristics such as their model, age, condition and location is crucial in order to determine when and how a PC or affiliate IT equipment should be processed. Our research also revealed that this database needs to be serviced and managed by dedicated individuals and the IT team. Overall, the University would not have been able to start implementing this reuse and recycle model without a few SRS-based individuals (trailblazers) who were dedicated to improving the efficiency of using PCs and reducing their recycling carbon footprint at the University. The participants pointed this out in the interviews as the most important factor for success.
2. *IS department processing PCs:* Another key factor is to have a team or department that is responsible for processing PCs and IT items once they are flagged up to have reached their performance cycle on the database.
3. *Partner organisations for recycling and reusing PCs:* The University cannot recycle items itself and has limited capacity for reuse. Here, it is important to bring external organisations on board to undertake this activity off campus. These organisations can either be for-profit or not for profit organisations, or a combination of both.

Figure 5 illustrates how the three key factors stand in relation to one another and how the PCs and IT items move along these key factors.

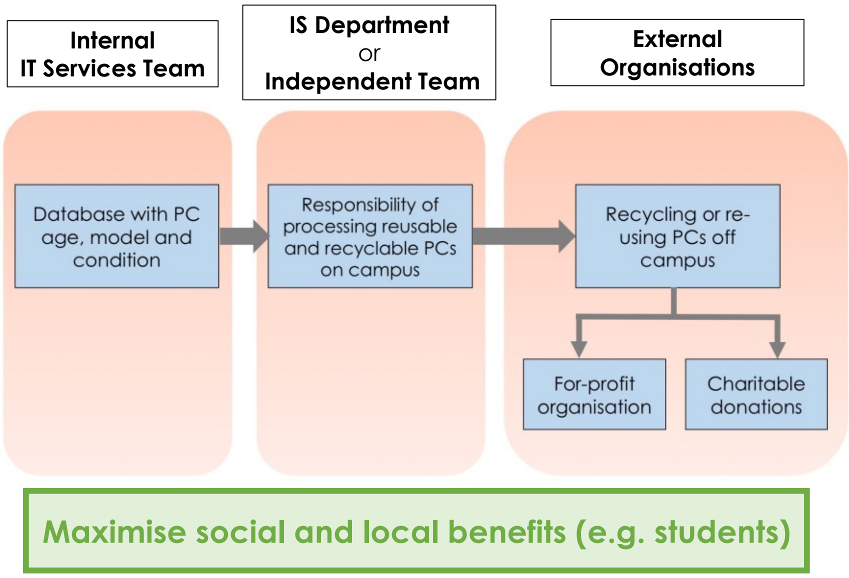


Figure 5. Key factors for success.

11. Conclusion

This report has shown how the University of Edinburgh reuses and recycles its PCs. We revealed how diverse stakeholders work together in order to be able to reuse PCs that have reached the end of their performance cycle at the University. Overall, it is evident that public-sector organisations can enable the reuse and recycle of products – although challenging and complex. The key to a successful delivery is the active participation of actors across society including waste contractors, charities, and members of staff.

This delivery model can be improved by focusing more strongly on making use of the local community as an end-destination for reused equipment. This can allow the project to economically run itself, independent of support of external grants. Furthermore, it also maximises its social impact: specific local communities and stakeholder groups could be targeted to access the IT items at discounted prices.

The unique and successful reuse model has shown that the University can operationalise a circular economy approach at an institutional level and that also going forward, ideally over the next year, other IT items and products from other sectors could be cascaded along the reuse pathway.

This report has shown that the notion and implementation of such a reuse model is neither new nor novel. However, it cannot be applied by one organisation on its own. It is therefore important for an organisation, with the assistance of a number of dedicated individuals, to step away from 'business as usual' models, have the difficult conversations and embark on new innovative routes to a circular economy. It is also crucial that external organisations and other stakeholders are identified early on. Profit maximisation should not be the main driver for action and all partners need to maximise their projects' social and environmental benefits *in parallel to* produce feasible returns.

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