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Assessing barriers to reuse of electrical and electronic equipment, a UK perspective

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ABSTRACT

This paper reports on research undertaken to identify generic and specific barriers to reuse of electrical and electronic equipment (EEE). Thirty semi-structured interviews were conducted with experts from across the value chain including product designers, manufacturers, users and waste managers as well policy makers and academics. The interviews sought to examine perceived and real barriers to reuse in the UK. Three inter-connected factors that limit opportunities and instances of reuse of electrical and electronic equipment were identified, highlighting that both systemic and consumer barriers to increasing levels of reuse exist. These are: producer reluctance, unsuitable collection infrastructure and cultural issues. Overall, the paper shows that low levels of reuse in the electrical and electronic sector are a result of complex and interlinked barriers. Understanding these connections offers the potential to improve the opportunities for reuse, by providing direction for policy makers to address barriers from a multi stakeholder perspective. Increasing instances of reuse is essential if the UK is to successfully move towards a resource efficient, circular economy.

1. Introduction

Discarded electrical and electronic equipment has become one of the fastest growing global waste streams (Baldé et al., 2015) due to rapidly developing technology, the increasing number of products containing electrical or electronic functions and decreasing product lifetimes (Laurenti et al., 2015). This in turn has increased global demand for a number of resources (Greenfield and Graedel, 2013) and led to particular concerns around the supply of critical raw materials (WRAP, 2011a, 2015a; EC, 2015a,b). Initiatives towards a circular economy (Stahel, 2016) are intended to address current and future resource concerns, and in the EU Circular Economy Action Plan (EC, 2015a,b) the inclusion of strategies to extend product lifetimes highlights the importance of reuse, particularly when value remains in working products and their components (Ellen MacArthur Foundation, 2013; Green Alliance, 2015) and many discarded items remain in a functional condition (WRAP, 2011b).

The importance of reuse has long been recognised in principle in national and international legislation on waste (EU, 2008). Direct reuse by passing, or selling, directly to a second owner is considered to be a waste prevention activity (Read et al., 2009). However, once an item is disposed of and enters the waste stream any further opportunity for reuse must be preceded by preparation for reuse, a waste management activity, which may involve safety testing, repair, cleaning or a combination of these activities (Ongondo et al., 2011; Kissling et al., 2013; Messmann et al., 2019). At this point it is far more likely that an item will be recycled. This is reflected in policy issues where recycling has dominated, despite reuse taking a higher position in the waste hierarchy through its greater environmental benefits (Williams, 2015). This dominance is also present in the academic literature, in which there are many articles on waste electrical and electronic equipment (WEEE) recycling but considerably fewer on EEE reuse.

Reuse has been represented in this literature in various forms:

- a waste treatment option (Bartl, 2014; Curran et al., 2007; Perez-Belis et al., 2015; Cole et al., 2019)
- a waste prevention strategy (Cox et al., 2010; Cole et al., 2014a; Zorpas and Lasaridi, 2013)
- a resource management strategy (Truttmann and Rechberger, 2006; Singh and Ordoñez, 2016; CIWM, 2016)

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- a material efficiency approach (Söderholm and Tilton, 2012; Allwood et al., 2011)
- an approach to reducing carbon footprints (Schanes et al., 2016; Barrett and Scott, 2012)
- a socio-economic opportunity (Hultman and Corvellec, 2012; Ongondo et al., 2013; CIWM, 2016) and
- an alternative type of consumption (Guiot and Roux, 2010; CIWM, 2016; Williams and Shaw, 2017).

Several authors highlight the difficulties facing reuse, with issues around obtaining sufficient quantities of suitable goods being difficult (Matsumoto, 2009; Kissling et al., 2013; Ongondo et al., 2013). Other challenges include customer acceptance (Gregson et al., 2013; Kissling et al., 2013; Mashhadi et al., 2016; van Weelden et al., 2016), particularly with concerns about reliability of any necessary repairs (WRAP, 2015b; Sabbaghi et al., 2017; Cole and Gnanapragasam, 2017) and data security (Ongondo et al., 2013). Improved reverse logistics (Kumar and Putnam, 2008; Cole et al., 2018), take-back schemes (Stevels et al., 2013; Singh et al., 2019), circular business models (Bocken et al., 2014; Lewandowski, 2016; Cherry and Pidgeon, 2018; Singh et al., 2019) and addressing consumer expectations of products (Gnanapragasam et al., 2018; Gnanapragasam, 2018) are all suggested as solutions. Other recommendations include ensuring promotional activities that raise awareness are undertaken (Ongondo and Williams, 2011a,b; Cole et al., 2014b), and introducing policy measures to address low instances of reuse (Whalen et al., 2018). Case studies are frequently presented, either depicting reuse organisations (Curran and Williams, 2010; Ongondo et al., 2013), processes (Curran et al., 2007; Zacho et al., 2018), specific products (Truttmann and Rechberger, 2006), or product groups (Geyer and Blass, 2010; Kogan, 2011; Bovea et al., 2016; Wieser and Tröger, 2018). These studies highlight the difference in opportunities for reuse that exist between different electrical and electronic product groups (Truttmann and Rechberger,2006; Oguchi et al., 2008).There are active markets for reusable IT items including personal computers, laptops, mobile phones and televisions (Ongondo and Williams, 2011a,b; Benton et al., 2015; Wieser and Tröger, 2018). However, advances in technology, such as the change from CRT TV sets to flat screens and the digitalisation of television network transmission, sometimes limit opportunities for reuse (Gusukuma and Kahhat, 2018). There is also an active market for the reuse of many large household goods such as refrigerators, freezers, dishwashers and washing machines (OöConnell et al., 2013; Perez-Belis et al., 2015). The opportunities for reuse of small household goods are more limited (Darby and Obara, 2005) due to the low initial costs leading to low residual value at the point of discard making these items less attractive for reuse.

Research specifically focussing on barriers to reuse has explored the barriers faced by reuse organisations (Kissling et al., 2013), consumer attitudes towards reused items (Cervellon et al., 2012), including the reluctance to purchase second-hand items (Schanes et al., 2016), the challenges that this poses to pro-environmental behaviour patterns (Young et al.,2010; Gregson et al., 2013) and the implications for retailers (Guiot and Roux, 2010). Additionally, studies have examined issues at particular points in a products' life cycle, for instance during design phase (Knight and Jenkins, 2009; Mestre and Cooper, 2017), and at the end-of-life or disposal phase (Bartl, 2014; Curran et al., 2007; Curran and Williams, 2010).

Legislative and regulatory barriers are also a recurring theme in the literature. For example, producer responsibility and the options available for its implementation which include collective producer responsibility, as operated in the UK, whereby all producers contribute proportionately (based on market share and type of equipment) to the costs of recycling (Mayers et al., 2013). In contrast another option is individual producer responsibility which creates economic incentives to encourage the design and production of electrical and electronic equipment to facilitate repair, reuse, disassembly, and recycling (Lindhqvist and Lifset, 2003; Rotter et al., 2011; Atasu and Subramanian, 2012). Additionally, the lack of legal enforcement to implement reuse ahead of recycling (Kissling et al., 2013; Cole et al., 2019) and legal definitions of waste which may impact on the availability of discarded items for reuse (Whalen et al., 2018) have received attention. Reuse organisations have traditionally received little policy support, but with the European Commission's current focus and future ambitions for a circular economy this appears likely to change (European Commission, 2015a,b).

This paper seeks to provide a holistic representation of barriers to reuse of EEE, specific to the UK context, by exploring stakeholder opinion across the value chain. It aims to identify the systemic and cultural barriers to reuse that determine why instances of reuse of electrical and electronic equipment remain low when technically feasible routes to reuse exist.

The next section outlines the research methods used. Section 3 reports on the data analysis, identifying three factors that limit the instances of reuse of electrical and electronic equipment and discusses how the inter-connected nature of these factors magnify individual barriers to reuse. This suggests that a multi-faceted approach is required to tackle them, taking into account the whole life cycle of products. Finally, the paper proposes a series of measures to improve opportunities for items to be reused by acting on the barriers identified.

2. Research methodology

This study utilised a critical interpretive synthesis method and thirty semi-structured interviews (Fig. 2). This section provides an overview of the methodological approach used.

2.1. Critical interpretive synthesis

Critical interpretive synthesis (Dixon-Woods et al., 2006), an approach to the synthesis of multidisciplinary and multi-method evidence, was utilised to analyse the literature, guide the sampling strategy and frame interview questions. This approach allows research questions to be refined iteratively enabling scientific enquiry to cross disciplinary boundaries (Seale et al., 2004).

Literature exploring challenges faced with end-of-life management of EEE, including collection, reuse and recycling, was studied and analysed. This included academic papers, industry and non-government organisations' reports, and EU and UK legislation. Responsibilities, interests, key themes and challenges were identified in order to obtain the evidence and opinions necessary to enable a thorough cross-sector investigation.

2.2. Sample selection

Interviewees were recruited using a purposive sampling strategy (Shenton, 2004; Palinkas et al., 2015), approaching known professionals in the electrical and electronics sector. Additionally, a convenience sample, composed of key informants identified by participants in the purposive sample, was used (Kelley et al., 2003).

Efforts were made to obtain a diverse sample of stakeholders across the EEE value chain, defined here as groups or individuals affected by, or who can affect, the recovery and treatment of WEEE (Figs. 1 and 2, Table 1). Interviewees were selected to offer different perspectives, operational experiences, campaigning strategies, motivations and principal challenges. Initial contact, by either email or telephone, allowed the researcher to explain the study and extend an invitation to take part.

Fig. 1. Interviewees' point of influence in policy and operations (pre-use phase of product lifetimes).

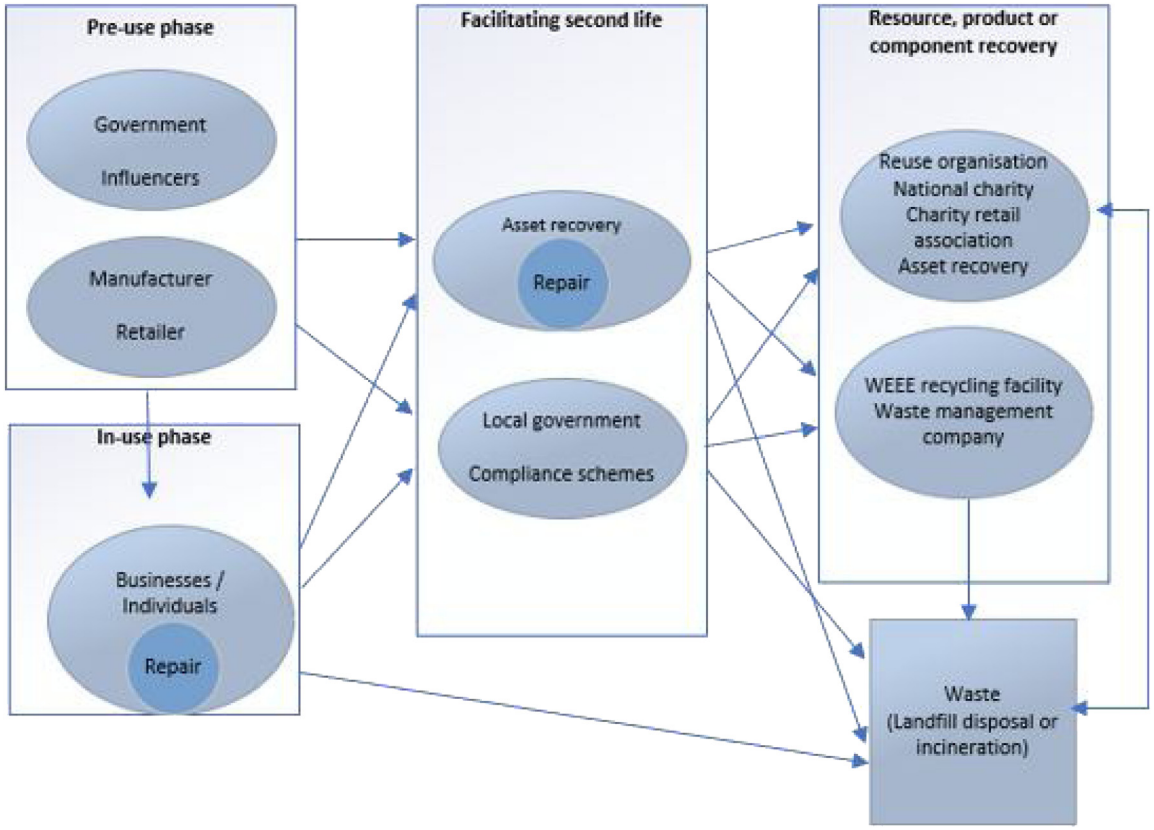

Fig. 2. Interviewees' point of influence in life cycle of electrical and electronic products.

2.3. Data collection

Thirty semi-structured, face-to-face interviews of approximately one hour were undertaken. Interviews were semi-structured to enable interviewees to shape their contribution and lead the debate towards topics central to their particular area within the life cycle of products (Fig. 3). This ensured different observations from interviewees (Galletta, 2001; Bryman, 2012), with discussions becoming more fluid than a structured interview (Bryman, 2012), providing greater insights into each interviewee's perspective.

A formal set of initial questions was prepared to ensure consistency and comparability, and that the objectives of the study were met. They were open-ended, providing some flexibility to expose insights that had not been anticipated (DiCicco-Bloom and Crabtree, 2006), and followed up with further questions where

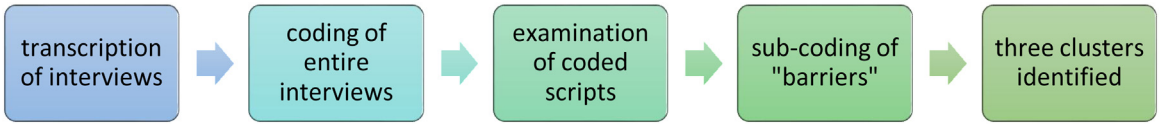

Fig. 3. Analysis process.

Table 1
Type of organisation represented in the interviews.

Interview reference	Type of organisation involved
001	Lobby group, Brussels
002	Government spokesperson
003	Compliance scheme
004	Reuse network
005	Asset recovery business
006	National charity
007	Compliance scheme
008	Lobby group, Brussels
009	Reuse and recycling company
010	Local government
011	Waste management company
012	Reuse company
013	Compliance scheme
014	Retailer
015	Government delivery body
016	Think tank, UK
017	Asset recovery business
018	Academic
019	Charity retail association
020	Academic
021	WEEE processor
022	Reuse retailer
023	Manufacturer
024	Government delivery body
025	Local government
026	Government spokesperson
027	Logistics company
028	Compliance scheme
029	Repair charity, UK
030	Repair campaigner, International

appropriate. One researcher conducted all interviews, minimising the effects of different personal interviewing styles (Irvine et al., 2013).

2.4. Analysis of interviews

Interviews were audio-recorded and transcribed. Data analysis ran concurrently with data collection, enabling earlier interviews to inform the recruitment of later interviewees (Galletta, 2001). Transcripts were coded using the NVivo© qualitative analysis software package, a computer-assisted qualitative data analysis (CAQDAS) tool used for coding, analysing and interrogating large volumes of text-based data (Silver and Lewins, 2014).

The data analysis process utilised Yin's (2009) general analytical framework. It involved open-coding, generating codes at different levels of theoretical complexity, from simple descriptions to conceptual categories, and constant comparison between and within codes to ensure good 'fit' with the data. It also required a process of (re)grouping codes within broader and more theoretically relevant meta-codes, identifying common themes, and establishing complementary and contradictory areas (Silver and Lewins, 2014; Silverman, 2015). This process continued until theoretical saturation was reached and no further new codes, themes or insights were generated. From coded data, responses relating to barriers to reuse were extracted and re-grouped into more definable categories to facilitate the presentation of data in a clear and concise way (Fig. 3).

3. Results

Reuse is an important strategy for optimising the use phase of products and prolonging product lifetimes and, as such, is included in circular approaches to the use of goods and materials. This section reports on empirical data relating to barriers to reuse that was collected during the interviews. Data analysis reveals three distinct, but interlinked, groups of barriers to reuse in the EEE sector: 1) producer resistance, 2) unsuitable collection infrastructure, and 3) consumer attitudes towards reuse (Table 2, Figs. 4 and 5). These factors influence the volume of goods available for reuse in the UK, which in turn determines resource efficiency and the success of waste prevention strategies. The groups of barriers are discussed below, supplemented with quotes selected from the interviews (Fig. 6).

3.1. Producer resistance

Several of the barriers to reuse that were identified appear to be producer-led, with interviewees suggesting that producers of EEE are reluctant to encourage, or facilitate, reuse. The reasons behind this are complex. Many interviewees suggested that this reluctance is to ensure a return from the investment in design and manufacturing processes, whilst others cited protection of brand reputation. Several mentioned the sales-driven focus of the sector:

> "Some manufacturers are still wary of reuse because they think it will damage their brand name and reputation by having (an) uncontrolled reuse and refurbishment sector." [019]

Concerns about brand reputation appear to be related to the reliability of goods in second ownership. This predominantly relates to aging or repaired goods, where manufacturers cannot influence who carries out repairs in the same way they can in the earlier life of a product where consumers wish to ensure guarantees or warranties remain valid. Several interviewees drew comparisons with the car industry, where sales of used cars do not raise concerns about brand reputation. One interviewee suggested this was because "they are not in direct competition" [002], as new and used cars appeal to different demographics. Within the second-hand car market an entry-level brand loyalty is created amongst customers currently unable to afford new items. One interviewee explained this with an example: "Mercedes do not resist the sale of used cars to younger drivers just because it's not new ... that driver may, later in life ... prefer their cars because they are familiar" [010]. He continued: "It's better to have a customer with you for a lifetime." The comparison between sectors is useful for identifying strategies that work with different products. Several interviewees mentioned the dominance of producer-led strategies that seek to increase sales rather than encourage product longevity. One interviewee stated:

> "The UK's set-up is producer-driven and sales of new dominate." [13]

Another blamed:

> "The structure of the industry, ever-ending contracts with upgrade options encouraging replacement purchases for perfectly working stuff." [022]

Table 2
Interview quotes illustrating barriers to reuse.

Producer resistance - Quotes from the interviews

Sub-coding	Comments	Interview
Brand issues	It's better to have a customer with you for a lifetime rather than trying to get them to buy in three or four years, when they're unhappy and go to another brand anyway.	017
	We're very much into buying names and badges	005
	Some manufacturers are still wary of reuse because they think it will damage their brand name and reputation by having uncontrolled reuse and refurbishment sector	019
Customer	The UK's set up is producer-driven and sales of new dominate	013
	We are very sales driven, not really reuse	016
	The structure of the industry, ever ending contracts with upgrade options encouraging replacement purchases for perfectly working stuff	022
	Very quick design turn-round and underlying structure of the industry to replace and upgrade before it stops working	022
Design	The design prohibits reuse effectively	013
Liability	Local authorities are wary of reuse because of fears of illegal activity, so they won't allow reuse	006
Marketing	The way its marketed and getting over it not being new	005
	There's not a resistance to buying reused, you see it in the car market	005
	Online search engines make it easier to find new things than second-hand things	010
	Saleability, selling and buying brands	011
Obsolescence	Products are not supported for long enough. That applies to both parts and software	009
	No one commits to providing software updates to keep the product you buy today working for five years. Not new functions, the ones you have when it's sold as new	009
	Product design – getting cheap parts to fail so that a machine needs replacing	017
	A design issue. . . for instance the variety of different power supplies, chargers etc. if they were standardised equipment could more easily be reused	019
	Technical obsolescence makes things not worth reusing	022

Unsuitable infrastructure – Quotes from the interviews

Sub-coding	Comments	Interview
Collection methods	They aren't discarded or collected in a way that preserves their functionality	012
	Perfectly usable but just chucked in a skip, or left in the open to get rained on	012
	What these things look like is down to handling, therefore we lose reuse potential	016
	How collection systems are organised	018
	Bring banks guarantee that anything taken there will be no good once it's dropped (from a height) onto a concrete floor	018
	Design collection systems so that working products aren't broken during collection process	018
	Collection systems aren't geared to do reuse	012
Damage	The high level of cosmetic finish required, once damaged goods don't meet up to this expectation, even if they are fully functioning, they won't get reused	003
	It really boils down to cosmetics . . . if it's gets scratched during collection . . . it ultimately gets broken down for recycling	016
Data issues	Concerns about the confidentiality and commercially confidential data that may be held on the computer memory	019
Handling	The way local authorities collect from households and HWRC sites doesn't lend itself to easy reuse because things get damaged	002
	If you handle a product badly, damage it, then that's it, even if it's only cosmetic it acts as a greater barrier than a technical fault which can't be seen	003
Improve routes to reuse	Reuse, yes, but It's not accessible	017
	If you treat it as potentially for reuse it'll be stored with greater care, mitigating damage, and it'll enable reuse to be more commercially viable	019
	It is just ease. People do whatever is easy. So, if there's a collection point at a place they go every week, or they can leave a bag outside for collection, that's easy, they will do it	021
Waste	Public think if you've taken it to the tip, then it's waste, no good to anyone	011
	if you treat it as waste it will be stored badly	019
	It's how the goods are considered at end-of-life	016

Cultural and behavioural issues - Quotes from the interviews

Sub-coding	Comments	Interview
Perception	Perception, the way reused is perceived, how can we overcome that?	005
	Perception . . . (of) what's suitable and acceptable	009
	The public "get" [understand] recycling. . . reuse is a harder concept to get across	011
	It's a bit of a mental block or lack of understanding about reuse	011
Reliability	Risk in terms of warranty or not knowing the past life or past use	027
	Fears of safety. Some sort of guarantee or warranty with it, to say that it's been inspected and has a period of warranty, would give them peace of mind	027
	Expensive to repair	012
	Reliability is a large barrier preventing compliance schemes working with reuse sector	017
	Lack of standards for best practice	019
Unsafe	Fear of safety standards	002
	Public perception of reuse and that it's difficult, dangerous, not acceptable	017
Waste	People worry that their things aren't good enough to resell.	021
	I understand the ethos. . . we should have reuse shops on CA sites, but I think it turns off a whole lot of people. . . 'I think I'll drop off two bin bags of rubbish and buy a washing machine.' Collect there, but I think the sales need to be on the high street	015

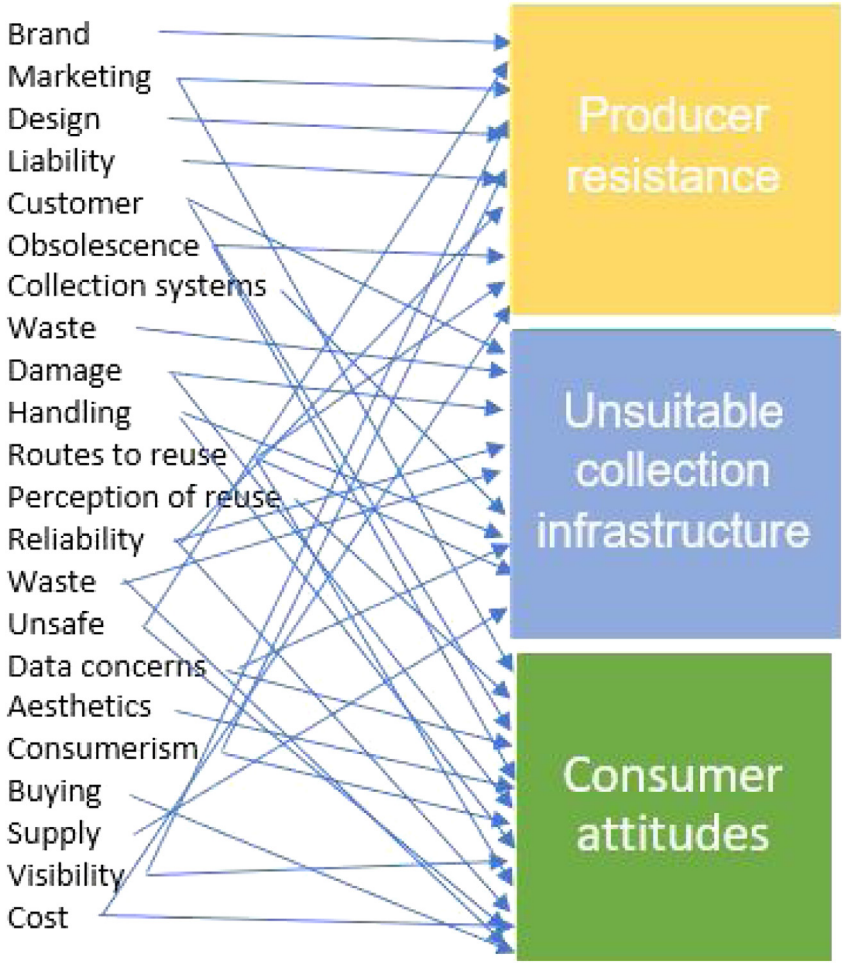

Fig. 4. Second phase coding, from open codes to four clustered factors.

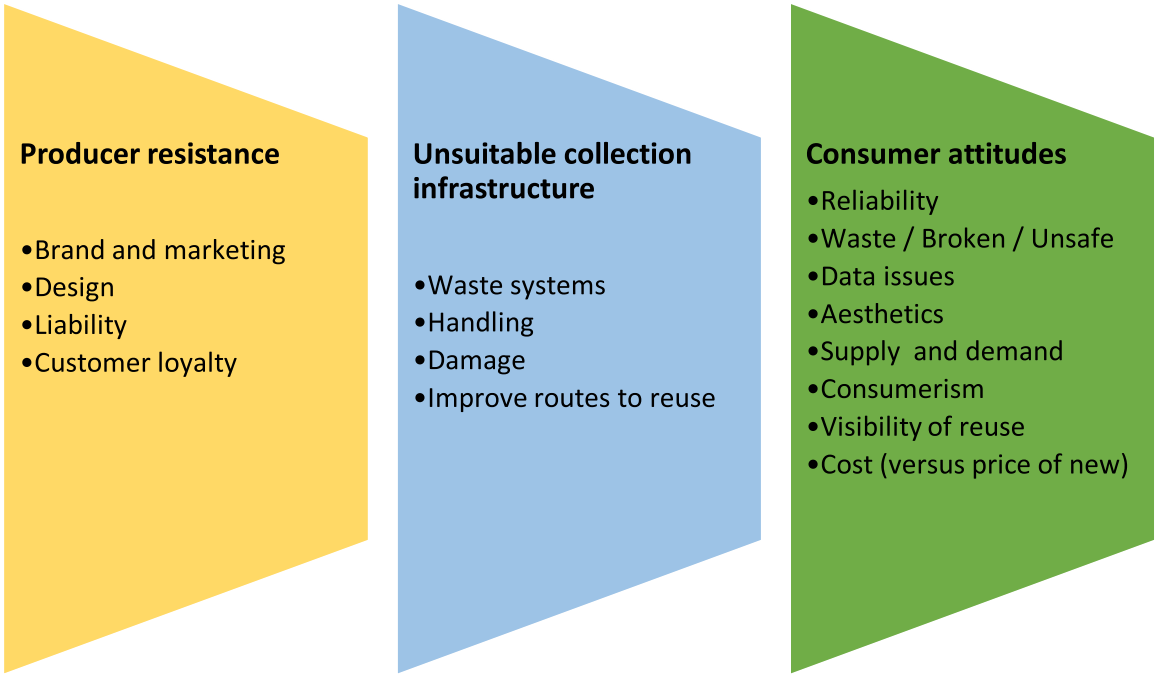

Fig. 5. Second-phase coding, from open codes to three clustered factors.

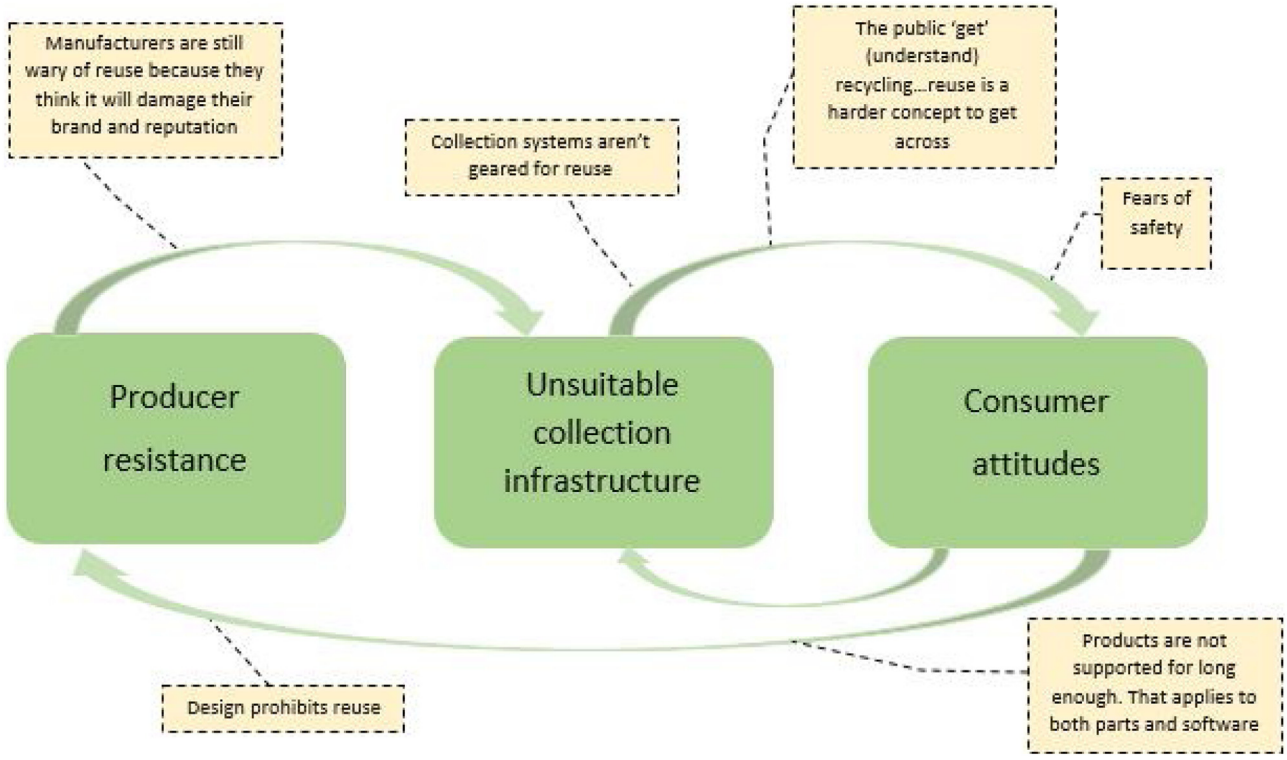

Fig. 6. Diagram illustrating the complex inter-connections between barriers to reuse.

Many interviewees suggested that manufacturers discourage reuse of EEE to prevent competition between new products and cheaper, second-hand goods, for example by actively discouraging sales of used goods alongside new items. For example, one compliance scheme operator indicated that "some manufacturers actively discourage reuse, and push for recycling" [011].

Design strategies employed by manufacturers also appear to be a barrier to reuse. For instance, using poor quality parts that may impede functionality early in a product's life: "getting cheap parts to fail so that a machine needs replacing" [017]. Similarly, poor after-sales care was mentioned: "products are not supported for long enough" [009]. Limiting availability of spare parts and access to repair instructions and imposing time limits on the provision of software updates were cited as further examples of poor practice that limited product lifetimes and acted as barriers to reuse.

Concerns were raised about the level of responsibility producers take for the end-of-life phase of products. It was suggested that producers should be more involved in improved reverse logistics operations or organising other collection services, with a local government representative proposing that producers should be financially responsible for collection systems:

> "There's a role there for the producers to kind of come in and say, 'Right, in order to help with this, we'll help fund local authority schemes." [010]

Whilst this is a rather simplified notion, it may have some foundation, the premise being that finance from producer responsibility schemes should directly fund collection systems for e-waste. Several interviewees stated that the current compliance scheme concentrates on achieving recycling targets in preference to maximising reuse because the cost is significantly lower. A compliance scheme operator stated: "the conundrum (is) ... the producer's prime interest is in keeping costs low" [003], which acts as a barrier to reuse. Another suggested that compliance scheme membership fees are viewed by some producers as an alternative to reducing the environmental impact of EEE: "producers pay lip service to reuse and waste prevention ... they look on it (compliance fees) as similar to carbon credits" [015], with the payment removing any further obligations for the impact of their products.

3.2. Unsuitable collection infrastructure

Discarded EEE is generally treated as a (post-consumer) waste management issue and most interviewees cited waste management practices as a major barrier to reuse. Careless handling during collection and transportation results in items becoming damaged, or further damaged, and any reuse potential they had diminishes. A government department interviewee referred to this:

> "The way local authorities collect from households ... doesn't lend itself to easy reuse because things get damaged." [002]

Another interviewee gave an example:

> "If it's scratched during collection ... it ultimately gets broken down (for recycling)." [016]

A further interviewee explained the problem:

> "(There is a) high level of cosmetic finish required. Once damaged goods don't meet up to this expectation, even if they are fully functioning, they won't get reused." [003]

Labelling unwanted items as 'waste' is often enough to prevent them from being reused. One interviewee commented "if you treat it as waste, it will be stored badly" [019], and another "(the) public think if you've taken it to the tip, then it's waste, no good to anyone" [011]. A further interviewee observed that collection systems are better suited to "last minute scrap salvage" [006] than usable goods recovery. Most interviewees felt that local authority waste collection operations are better suited to moving things quickly than carefully. Waste disposal processes such as recycling, landfill and incineration are consequently the dominant routes for discarded EEE because they take less effort than collecting for reuse

and are cheaper. A local government interviewee cited this as a major barrier to reuse:

> "waste management companies operate 'for profit'; some invest in reuse, but most want the cheapest way to process items and that's recycling." [011]

Recycling is an important part of the treatment of discarded EEE. In contrast to the experiences listed above there are examples of successful reuse organisations operating on a business to business (B2B) basis. Operating as asset management services, goods are retrieved on a regular basis, tested, cleaned, repaired and resold. This quite profitable business is explained here:

> "we work with organisations that refresh equipment every two or three years, which is great because there's good residual value left in it for us" [005]

This organisation goes to great lengths to avoid items entering the waste stream, goods are either collected or delivered directly to their facility in secure transport systems. Transporting in this way ensures any reuse potential is maintained.

The interviews demonstrated that reusable items should not regarded as part of the waste stream and instead of being subject to waste management, trained staff should handle recovered goods carefully as a way of ensuring that reusable items retain their potential. Such a system may be organised separately, or perhaps utilise the reverse logistics networks of retailers.

3.3. Consumer attitudes

The supply of good quality electrical and electronic equipment with reuse potential was regarded as a key challenge to the reuse sector. Several interviewees mentioned that this issue affected their organisations and "getting hold of reusable items" [007] was a barrier to increased reuse:

> "Access to suitable material in a good enough state to sell as second-hand." [008]
> "(the) availability of suitable volumes and quality of materials." [027]

One interviewee went further, blaming "the current regulatory framework", which he felt "does not adequately support reuse organisations to access sufficient volumes of goods" [004]. He suggested amending legislation to address the difficulties that the sector has in accessing reusable goods to sell.

Whilst the supply of reusable items was a problem, inadequate demand for second-hand goods was also cited as a barrier to reuse. One interviewee argued that "the psychology in this country is to have a really cheap, brand new thing" [010] and others stressed the reluctance of some consumers to purchase second-hand goods, preferring new items instead. One suggested that "getting over the snobbery of buying a reused piece of equipment" [005] was a challenge for reuse retailers, another that "many people are willing to donate (for reuse) but are reluctant to purchase" [026], a further interviewee suggested that reused items have to compete against new items on cost, appearance, availability and, in a throwaway society, the "desire to have the next, best and latest thing" [002].

Consumer perceptions of reusable items was often cited as a barrier to reuse, with concerns expressed about reliability, product lifetimes, the need for costly repairs and fears about safety. Additionally, it was felt there was a 'cultural issue', with British consumers preferring new goods:

> "(the) British need educating about reuse. Here, reuse is ... something poor people do."[010]

This interviewee's company accepted used goods from major retailers through take-back schemes because, as another interviewee noted, "there are lots of working products in the return stream" [016]. Many goods reused using this route are exported to the Netherlands and Spain where, the reuse and recycling company interviewee [010] suggested, reuse is more widely accepted. Changing the perceptions of reuse in the UK could extend the market to groups of people who do not currently purchase reused items:

> "There is potential to market good quality second-hand items that are easily repaired and don't often break to students and new families." [010]

This interviewee also felt that consumer preference for reuse varies between products. His company concentrates on white goods, televisions and laptops because such items retain value beyond the first user. Again, the success of reuse in the car sector was mentioned: an interviewee from a charity with many reuse shops commented: "we expect to be able to sell a car on to someone else. That's reuse" [029]. The market for used cars offers buyers a level of reassurance about the condition of their purchase: selling through accredited dealerships, with maintenance records and warranties or guarantees, is seen as trustworthy and an established route to reuse. Replicating this in the EEE sector, by similarly issuing warranties or guarantees, could address safety concerns such as fires and electric shocks, both of which were cited by interviewees.

> "To avoid fears of safety... (give) some sort of guarantee or warranty with it to say that it's been inspected and has a period of warranty (that) would give them peace of mind." [027]

Views expressed about the use of standards for the management of goods within the reuse sector varied from "essential" to "not much use." The existing BSI standard, PAS141, was described as being too "waste-orientated" [004], and several interviewees felt that it has not helped to increase the level of reuse. The Revolve Standard in Scotland was cited as an example of best practice to encourage the resale of goods to a wider audience.

The range of barriers affecting both supply and demand creates a sales challenge that could be addressed by adopting a standard for reuse to increase confidence in goods and leading to changed perceptions and increased sales.

4. Discussion

Barriers to reuse identified in this research were clustered into three distinct but interacting factors: producer resistance to reuse, unsuitable collection methods, consumer attitudes. The inter-connected relationships between these factors influence the quality and quantity of items available for reuse and impact on the market for used goods. Addressing any one of these issues in isolation will not unlock the barriers to reuse. For instance, ensuring all retailers instigate a take-back scheme for discarded products would ensure items with reuse potential are captured for resale, but the barriers relating to consumer attitudes to reuse also need addressing to ensure these items do reach second and third owners. Consequently, a holistic approach is required, seeking to limit any unintended consequences at a different point in a product's lifetime.

It has long been argued that the way producer responsibility is currently operated in the UK requires amendment (Lindhqvist and Lifset, 2003; Rotter et al., 2011), with the responsibility for the post-consumer phase of a product's life remaining with producers. But this has been resisted by producers (Mayers et al., 2013). During the interviews it was suggested that some producers view their membership of compliance schemes in a similar way to carbon credits, paying for minimum compliance without taking any actions to improve their products' designs to limit the environ-

mental impact at the end-of-life stage. Imposition of individual producer responsibility may go some way to preventing this with producers directly benefitting from investment in eco-design that leads to improvements in the end-of-life impacts of their products.

Waste management companies have been innovative in developing recycling facilities (Salhofer et al., 2016; Cole et al., 2019) to meet legislative requirements for end-of-life EEE (Ongondo et al., 2011). However, this may also create a barrier to reuse because collection for recycling is far easier, quicker and cheaper than collection for reuse (Khetriwal et al., 2009). Our research provides evidence from a wide range of experts to show that discarded electrical and electronic items are most likely to be directed to recycling facilities in which shredding technologies are used to salvage easily recoverable, recyclable materials in large quantities. Furthermore, where examples of successful reuse operations exist they mainly capture reusable products before they enter the waste stream.

Consumption patterns that result in a throwaway society are complex and difficult to address (Gregson et al., 2007, 2013; Guiot and Roux, 2010; Gnanapragasam et al., 2018). Our research uncovered some consumer perceptions of reuse that act as barriers including a conflict between the cost and perceived value of reused products, fears around reliability and safety reflecting concerns about the previous owner's use of goods and their condition and suitability for continued use. The development of a generic standard, or quality label, for reused EEE that provides better, reliable information about functionality and age could assist in addressing issues of public confidence when purchasing second-hand items. Our research recognises the Scottish Revolve Standard as an example of best practice; it signifies a quality guarantee, strengthening confidence of suppliers, authorities and consumers in the quality and safety of items on sale for reuse. The wider adoption of this standard for reuse, or a similar UK-wide standard, would support a more positive perception of reuse.

Whilst our research recognises that recycling meets the legislative requirements for the treatment of WEEE, it does not achieve the potential environmental benefits (i.e. lower volumes of waste, material and energy consumption and reduced carbon emissions) possible from extending product lifetimes by facilitating reuse (Truttmann and Rechberger, 2006; Castellani et al., 2015). As proactive management of environmental issues becomes more critical for addressing the impacts of climate change (Barrett and Scott, 2012), diminishing supply of finite resources (Singh and Ordoñez, 2016) and moving towards a circular economy (Stahel, 2016) there is a need to address the barriers to reuse of electrical and electronic equipment, such as those identified in this research.

5. Conclusion

This paper investigated expert opinion on barriers to reuse of electrical and electronic equipment through a series of semi-structured interviews across the across the value chain. This included product designers, manufacturers, users and waste managers as well policy makers and academics. The interviews explored perceived and real barriers to reuse in the UK. The research identified both systemic and cultural barriers to reuse. Furthermore, these barriers are interconnected in nature and require a holistic approach, with interventions coordinated across the value chain.

As a result of the interviews, the following recommendations are made to overcome barriers to reuse: a change of approach on producer responsibility to focus on individual rather than collective responsibility, the removal of end-of-life EEE from the waste stream, the adoption of a UK-wide standard on reuse and the adoption of more sustainable consumption practices.

Decision makers need to be ambitious in order to exploit the potential environmental gains associated with reuse. In summary, the necessary action, across all life cycle stages, includes encouraging the use of goods for optimum lifetimes, improving the handling of discarded goods to maintain their 'reuse potential', changing the perception of second-hand goods, and facilitating and enhancing systems that lead to reuse in preference to recycling and other forms of waste disposal.

Collectively, these measures would extend product lifetimes and thereby reduce the use of virgin materials. Finally, as political and economic factors, as well as consumer behaviour and attitudes, influence the attractiveness of reuse, addressing these both nationally and at EU level offers the possibility of reducing the significant detrimental impacts on the environment of end-of-life electrical and electronic equipment.

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