

Reuse of white goods components

An interview study on drivers, barriers, and the future outlook

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Abstract

The growing threat of resource depletion has spurred on the need to change how we consume. Old, linear modes of production must be replaced by an approach that reduces waste and maximizes value throughout the product's entire life cycle. This strategy is embodied by the Circular Economy (CE). A key aspect of CE is reuse, referring to the repurposing of old products to avoid generating waste and demand for new resources. White goods are particularly good candidates for reuse due having long lifetimes and because they can often be repaired by replacing defective components. While research has been conducted on the topic of white goods reuse, less is known regarding the reuse of white goods components.

This study set out to identify drivers and barriers for reusing spare parts from white goods and determine the future outlook of industry stakeholders. This was done by interviewing various actors within the reuse- and white goods industry, and by conducting a complimentary literature review. The study shows that while the future outlook among industry stakeholders is largely optimistic, there are several obstacles for harvesting spare parts from white goods. These obstacles include a lack of strong policy incentives for reuse, concerns among consumers regarding the quality of reused goods, products not being designed for easy dismantling, and other factors diminishing the profitability of harvesting spare parts. The study also reports on suggested actions for policy makers, reuse organizations and other actors to mitigate these issues.

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Abbreviations

CE	Circular Economy
EU	European Union
EEE	Electrical and Electronic Equipment
EPR	Extended Producer Responsibility
IPR	Individual Producer Responsibility
OEM	Original Equipment Manufacturer
PRO	Producer Responsibility Organization
VAT	Value Added Tax
WEEE	Waste Electrical and Electronic Equipment

1. Introduction

1.1. Problem definition

The growing global demand for resources has led to concerns regarding the supply of critical raw materials (Cole et. al 2019). Suboptimal use of resources in the products we consume is increasingly being recognized as unsustainable and can be linked to several facets of production and consumption. This includes insufficient recycling of materials, missing information on the environmental impacts of products, prices of products not reflecting environmental and societal costs and a lack of repairability leading to premature obsolescence (European Commission 2019). Mitigating these issues requires an approach that strives to maximize the value of our resources by promoting product durability, repair, reuse and the recycling of materials. Circular Economy (CE) embodies this strategy—to minimize negative environmental, economic, and societal impacts through a multi-faceted approach to improved resource efficiency (European Commission 2019).

Reuse, referring to the avoidance of waste through the repurposing of existing products, has been identified as an important building block of CE, providing benefits such as waste reduction, increased product longevity and lower carbon emissions (Cole et. al 2017). The waste hierarchy introduced in the European Union (EU) Waste Framework Directive (2008/98/EC) ranks reuse above the recycling of materials in terms of environmental benefits. Furthermore, the Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU) and Ecodesign Directive (2009/125/EC) has established product design requirements to promote resource efficiency, and new eco-design regulations were recently implemented for specific groups of electrical products—citing demands for repairability, availability of spare parts and access to maintenance information from manufacturers (Dalhammar et. al 2020).

Among the product categories being regulated are household appliances commonly referred to as white goods. These products are particularly good candidates for reuse, as many of them are currently being discarded even though only slight repairs are necessary to restore functionality (WRAP 2011). When it comes to products like dishwashers and washing machines, the most common failures can be attributed to defective components, making access to spare parts essential to enable cheap and effective repair (Tecchio et. al 2019). The availability of affordable spare parts is currently low, but one way to mitigate this could be to enable the reuse of components from disposed products (Deloitte 2016, Dalhammar et. al 2020). To promote reuse of

white goods and other electrical and electronic equipment (EEE) it is also important to develop our understanding of reuse organizations (Cole et. al 2017).

While research has been conducted on the topic of reusing white goods, less is known regarding the reuse of components. It is therefore important to investigate the current climate for component reuse for white goods: which drivers and barriers exist and how this branch of sustainable business is set to develop in the future.

1.2. Aim and research questions

The aim of this study is to identify important drivers and barriers for the reuse of white goods components and determine the future outlook among industry stakeholders, to illuminate possible pathways toward a circular economy in this area.

The research questions are:

1. What are the drivers and barriers for the reuse of white goods components?
2. What is the future outlook of stakeholders on the reuse of white goods components?

1.3. Scope

The scope for the interview study is geographically focused on, but not strictly limited to, Scandinavia. It includes interviews with people working directly with repair and reuse of white goods and white goods components, as well as researchers. The literature review is focused on the EU, as common EU regulations applied in all EU member states are especially relevant for identifying drivers and barriers. The study focuses on drivers and barriers for reuse and does not consider broader questions, such as whether adopting new, innovative technology can sometimes be more environmentally beneficial compared to reuse. Furthermore, this study specifically concerns the reuse of white goods components and does not provide a comprehensive picture of drivers and barriers for broader reuse and repair practices. For a broader perspective on reuse, the reader may consider looking into the CREACE project that aims to promote the repair sector in Sweden (Lund University 2020).

2. Method

Qualitative methods were deemed appropriate for this study, as it deals with the opinions and subjective impressions of stakeholders in the reuse industry. Semi-structured interviews were chosen as the preferred format to allow for the exploration of unpredicted aspects of reuse that could be relevant to the research questions. A literature review was chosen as a complementary method to provide scientific context to the interviews by reviewing the current knowledge on drivers and barriers for the reuse of white goods components.

2.1. Literature review

The purpose of the literature review was to provide a broader context to the study and allow for comparisons between the interview results and current research. The selection criteria therefore included: the reuse of components or spare parts being referenced in the literature, the research being conducted in countries affected by EU legislation, and articles being published no earlier than 2010. The search was conducted using Google Scholar and LUBsearch and the snowball method was used to identify additional relevant sources. The keywords used were: white goods, repair, reuse, spare parts and components (see table 1). The results were sorted according to relevance using the search engine settings, and the top 3 pages were examined for studies matching the above-mentioned selection criteria. The literature search and selection resulted in a total of 7 sources used.

Table 1
Keyword configurations and number of hits generated.

KEYWORDS	SEARCH ENGINE	HITS
"White Goods" AND (Repair OR Reuse)	Google Scholar	7210
"White Goods" AND (Repair OR Reuse)	LUBsearch	2472
"White Goods" AND Reuse AND Components	Google Scholar	6750
"White Goods" AND Reuse AND Components	LUBsearch	9
"White Goods" "Spare Parts" Reuse	Google Scholar	479

2.2. Interview study

The purpose of the interview study was to gather the impressions of industry stakeholders on drivers, barriers, and the future of reusing white goods components. The interviews were semi-structured to allow for the interviewees to expand on their unique perspectives, which may not have been predicted by the interviewer beforehand. Some interview questions were therefore designed to be broad and open-ended. While the questions were designed to be as neutral as possible, it should be noted that the interviewees were aware that the interviewer had an academic background in environmental issues. It is therefore possible that the interviewees unknowingly embellished their viewpoints to align with the interviewer's.

The interviews were conducted by telephone or Zoom. The interviewees were informed regarding the purpose of the study and consent was secured for their participation and for recording the interview. The interviewees (see table 2) were chosen based on their relevance to the study and the snowball method was used to identify additional candidates. Professionals from the repair sector, producer responsibility organizations (PRO), original equipment manufacturers (OEM) and researchers were included.

Table 2

List of interviews, the interviewee's field, interview type, and date.

INTERVIEW	FIELD	INTERVIEW TYPE	DATE
Interview 1	Researcher	Zoom	24/9 2020
Interview 2	PRO	Zoom	28/9 2020
Interview 3	Repairer	Telephone	1/10 2020
Interview 4	Researcher	Zoom	2/10 2020
Interview 5	PRO	Zoom	9/10 2020
Interview 6	OEM/Service provider	Zoom	12/10 2020
Interview 7	Repairer	Telephone	13/10 2020

2.3. Analysis

The literature was examined, and information deemed relevant for the research questions were collected. The interviews were transcribed and examined, collecting any information or perspectives deemed relevant for the scope and research questions. The content in the literature review and interview study were each sorted according to common themes, such as the type of drivers or barriers being discussed. The material was then condensed into a more easily readable format. In the interview study, statements from different interviews were summarized as common viewpoints when applicable. The interview material was interpreted to a certain extent, while remaining faithful to the original content and wording.

3. Results

3.1. Literature review

3.1.1. The EPR system

The WEEE Directive (2012/19/EU) enforces the producer responsibility principle by making producers responsible for the waste generated by their products. This manifests in the extended producer responsibility (EPR) system, where waste is processed in a common collection system and recycled (Dalhammar et. al 2020). According to Dalhammar et. al (2020), the EPR and WEEE Directive are barriers for reuse, because products that enter the EPR-system and are classified as waste are subject to legal restrictions. Cole et. al (2019) echoes this sentiment, stating that once a product enters the waste stream it is far more likely to be recycled as opposed to reused, and that this reflects how recycling has dominated policy issues despite holding a lower position in the waste hierarchy compared to reuse. Additionally, producers are incentivized to promote recycling over reuse because the recycling process is generally cheaper (Cole et. al 2019). A suggested solution in an interview study by Dalhammar et. al (2020) was to replace the current EPR system with an individual producer responsibility (IPR) system, where each producer is financially responsible for the waste generated by their products. Having individual fees for producers based on the reparability of their products could also help to provide economic incentives for repair practices over recycling (Dalhammar et. al 2020). A general lack of legal incentives was also identified by Bovea et al. (2017) as a barrier for repair in Spain.

3.1.2. Consumer demand

One of the most important drivers for repair is consumer demand (Dalhammar et. al 2020). Bovea et al. (2017) writes that unpredictability in both supply and demand is a barrier for the repair sector. According to Tecchio et. al (2019), a common reason for why consumers decide against repairing white goods is the high cost of repair services—including the price of spare parts, which could be lowered by reusing components. However, interviews conducted by Dalhammar et. al (2020) suggests that lowering the cost of repairs using tax deductions in Sweden did not increase the willingness to repair white goods. A suggested reason for this was that the price of the product—rather than the cost of repair—is more important for the consumer's decision, with consumers being more likely to repair expensive, high-quality products.

However, the availability of cheap new products was also seen as a barrier (Bovea et al. 2017, Dalhammar et. al 2020).

Interviews in the United Kingdom by Cole et. al (2019) also indicated that consumer demand for second-hand goods is a major barrier for reuse and suggested that consumer culture is an important factor. According to some interviewees, part of the problem stems from having a society where the next, best and latest thing is always desired. Others cited consumer perception of reused items—such as being unreliable, unsafe, short lived or having greater need for repair—as barriers for reuse. A suggested solution was to sell reused goods through accredited dealerships or with some kind of quality label or warranty, which could help offer the consumer a higher level of reassurance (Cole et. al 2019).

3.1.3. Product design

The ease with which a product can be separated into components depends greatly on the initial design (Tecchio et. al 2019). According to Bovea et al. (2017), difficulties in disassembling products is a major barrier for repairers. Lack of access to cheap spare parts was also identified as an obstacle (Bovea et al. 2017). If products were designed for easier dismantling and improved access to inner parts it could increase the availability of spare parts, benefitting both the repairability of old products and allowing for higher recovery of materials in cases where repair is not an option (Tecchio et. al 2019, Deloitte 2016). Interviews conducted by Cole et. al (2019) suggests that producers are unwilling to design for easier reuse due to fears that an uncontrolled reuse sector could damage the reputation of their brand. Promoting recycling over reuse could also be a way for producers to avoid competition with second-hand markets. A suggested solution for this was to implement an IPR system to strengthen economic incentives for producers to design for reuse (Cole et. al 2019). Product design is currently being incentivized in the WEEE Directive (2012/19/EU) and regulated in the Ecodesign Directive (2009/125/EC), with one demand being that products should be designed for easy dismantling.

3.1.4. Additional drivers and barriers

To promote the reuse of spare parts, Tecchio et. al (2019) suggests that better collection and storage efficiency for used spare parts is needed, and that information regarding product disassembly must be available. The latter is regulated in recent additions to the Ecodesign Directive (2009/125/EC), demanding that product information that facilitates repair is provided by manufacturers. Bovea et al. (2017) writes that high transport and labor costs, and a lack of standard protocols are also barriers for repair.

3.2. Interview study

3.2.1. Policy barriers

When asked about policy barriers for reusing white goods components, most interviewees agreed that the current implementation of producer responsibility favors recycling over reuse (Interviews 1, 2, 4, 5 & 7).

Several interviewees pointed out that the logistical requirements for reusable goods are very different from that of waste, where maintaining the condition of appliances and their components is not a priority. They emphasized the importance of identifying reusable products or parts before they enter the waste stream to avoid poor handling during transport (Interviews 1, 2, 4 & 5). One interviewee said that a separate collection system for reusable goods is required, explaining that making normal waste transports gentler is not an option, since this would probably increase the environmental cost of transport enough to offset the environmental gains from reuse (Interview 2). Another interviewee suggested that reuse organizations should intervene as early as possible in the supply chain, preferably when the old appliance is replaced, to keep the product and parts in the best possible condition (Interview 4). According to another interviewee it is also important to avoid labelling reusable goods as waste, since legal restrictions on waste would make them harder to sell (Interview 1). An interviewee from a PRO said that they try to avoid these issues by having small, local reuse centers which can pick up reusable items before they are absorbed by the waste stream (Interview 5).

The lack of mandatory reuse targets, as opposed to the recycling quotas that already exist in many countries, was highlighted by one interviewee who explained that this results in PROs being geared primarily toward recycling instead of reuse. The fact that reuse practices subtract from the available waste needed to meet recycling quotas makes the incentives to reuse even weaker (Interview 4). However, another interviewee said that with their country's legislation reuse does not subtract from the recycling quota. They also mentioned that while they did not have national targets for reuse, local targets within municipalities had proved to be a major driver for reuse practices (Interview 5).

The recent Swedish law (2016:1067) regarding tax on chemicals in certain electronics was criticized by two interviewees, who said that it negatively impacts the profitability for remanufacturers (Interview 1 & 2). One interviewee claimed that the tax makes some reuse practices economically unfeasible and described it as counterproductive (Interview 2).

3.2.2. Consumer demand and attitudes

Consumer demand was brought up as an important factor by all interviewees (Interviews 1-7). Two interviewees said that environmentally conscious attitudes among consumers is a driver for reuse (Interview 1 & 7). However, another

interviewee claimed that consumer demand for reused products or components is still too small to have any real impact on the market, and that most consumers are driven by economic factors rather than environmental concern. They explained that individual consumers are not always rational actors, and that they are more likely to forgo repair in favor of a new product if the price difference is too small (Interview 2). This was echoed by another interviewee, who stated that pricing is the most important factor for the consumer. However, they also said that consumers want to be able to repair their products, and that this has created a demand for more repair-friendly business models (Interview 6). One interviewee said that their customers will buy reused items even when the price difference is very small and attributed this to environmentally conscious attitudes (Interview 7).

Most interviewees also stressed the importance of quality assurance for generating consumer demand (Interviews 1, 3, 4, 5 & 6). According to one interviewee, someone must provide guarantees for the reused parts for consumers to feel secure in using them (Interview 1). Another interviewee suggested that longer warranties is a major advantage that new appliances have over reused goods (Interview 4). However, one interviewee claimed that their customers are willing to accept a lower warranty because they want to purchase sustainable goods (Interview 7). One interviewee mentioned an industry organization that is developing their own brand for reused products as a sort of quality label. This brand is also meant to prevent confusion regarding who is responsible for the warranty for the reused product (Interview 5).

Some interviewees suggested that consumers are more comfortable with buying reused parts or appliances if they are supplied by the original manufacturer (Interviews 1, 4 & 6). One interviewee also said that consumers are more likely to purchase reused goods from premium brands with a good reputation (Interview 1). While one interviewee argued that it makes common sense to use spare parts that closer match the expected lifetime of the machine being repaired, as opposed to putting a brand new part in an old product (Interview 2), another interviewee doubted whether consumers would actually be willing to invest in parts with shorter lifetimes, even for older appliances (Interview 3).

Consumers are less willing to repair when the costs of doing so are uncertain, according to one interviewee from the service department of a large OEM. They explained that a fixed price repair business model, where repairers offer an initial price that does not change it even if the job turns out to be more expensive, significantly increases the willingness to repair. This has been demonstrated in the company's test trials and has resulted in subsequent plans for a complete transition to this model. Repairers using a fixed price for their services can increase profitability by using reused components. Reducing the price of repair if consumers are willing to accept the use of reused components, was considered by the interviewee to be an interesting possibility (Interview 6).

Surveilling products to enable timely repairs is something that could provide peace of mind for the consumer, and one interviewee suggested that consumers would probably be willing to pay for such a service (Interview 6). Another interviewee agreed that tracking the use of appliances would promote repair but added that this poses ethical questions regarding who has access to the data (Interview 1). A tracking system

for documenting the maintenance done on a product was also suggested by an interviewee, arguing that it could add much needed transparency to the repair process (Interview 2).

3.2.3. Product design

Several interviewees agreed that improved product design could promote the reuse of spare parts by allowing easier access to valuable components (Interviews 1, 2, 5 & 7). Two interviewees highlighted that some producers may use glue or even weld components together, making it harder to harvest the parts (Interview 5 & 7). Another interviewee suggested that components that are commonly worn out should be positioned in a manner that facilitates replacement (Interview 2). Two interviewees said that some manufacturers design their products a certain way to actively prevent remanufacturing and avoid competition with second-use markets (Interview 1 & 7). This is likely something that requires legal intervention, making it mandatory for companies to facilitate repair by independent actors (Interview 1).

Three interviewees said that the high variability of components across different products makes it less profitable to harvest spare parts, since it requires a huge storage space to account for all the different models (Interviews 3, 4 & 6). Two interviewees also described cataloguing all the different parts as a big challenge (Interview 4 & 6). These issues could potentially be mitigated by some form of standardization for parts across different products and models (Interview 3 & 6). One interviewee suggested that having fewer products with higher quality would also improve the situation (Interview 6). Another interviewee pointed out that products and components with high quality are also more likely to be reused (Interview 5).

Elaborately constructed products are prone to breakage and are harder to repair, according to one interviewee who suggested that the current focus on advanced, unnecessary features is a big problem. These features are not necessarily driven by consumer demand, but rather by engineering whims and as an excuse to inflate prices (Interview 6). Another interviewee brought up the idea that some advanced features may enable preemptive maintenance by informing the user which components are likely to need replacing after a certain time and usage (Interview 1).

3.2.4. Economic drivers and barriers

Regarding the consumer's decision to repair and reuse, most interviewees agreed that economic factors are very important (Interviews 1-6). One interviewee pointed out that the reuse of spare parts is already common in the automotive repair sector and suggested that lower service costs are a major reason for the success of this business model (Interview 1). This was echoed by another interviewee, who explained that when they implemented spare parts reuse at a large automotive manufacturer, customers wanting access to cheaper parts was the main driver (Interview 6). A third interviewee added that spare parts in white goods and other electronics can be

expensive, making some repairs financially untenable for the consumer, and argued that reused components could provide a cheaper alternative (Interview 2).

Some interviewees emphasized the small price difference between new and reused appliances or spare parts as a problem (Interviews 3, 4 & 6). As one interviewee explained, the largest competitor to maintenance is the selling of cheap new products (Interview 6). This is because a small price difference between new and reused goods is easily overshadowed by other benefits, such as longer warranties (Interview 4). Another interviewee stated that this is especially true for white goods since they tend to be quite old when they stop working, at which point repairing them seems even less attractive when compared to buying a new appliance (Interview 3).

Regarding the business side of component reuse, many interviewees conveyed a perceived difficulty in making the business model economically viable (Interviews 1-5). One interviewee emphasized the importance of strong economic incentives, stating that serious businesses need to make serious profits, and that we should avoid a situation where reuse businesses have to cut corners (Interview 2). Another interviewee suggested that balancing financial incentives between reuse and recycling could be very difficult and that the focus should instead be on implementing direct legislation, such as mandatory reuse targets (Interview 4). One interviewee suggested that tax incentives, such as removing the value added tax (VAT) for reused goods, could be used to increase the profitability for reuse organizations (Interview 7).

Several interviewees brought up the high cost of labor associated with spare parts harvesting as a major barrier (Interviews 3, 4, 6 & 7). One interviewee stated that the need to hire specialized technicians to dismantle the appliances diminishes the profitability of component reuse, casting doubt on whether reusing spare parts can be a competitive business strategy (Interview 3). Another interviewee added that knowledge on databases, web design and logistics are also necessary to run the whole operation effectively. They also highlighted the lack of access to skilled technicians as a barrier, suggesting that modern attitudes regarding practical hands-on skill could be a barrier (Interview 4). However, another interviewee stated that access to competent workers is not the limiting factor, but rather that the initial investment in large storage facilities is (Interview 6). One interviewee brought up the lack of access to technical information as something that makes harvesting components more time consuming and expensive, saying that OEMs are unable to provide this information due to it being protected by proprietary rights. However, the interviewee thought that the new EU legislation could potentially mitigate this issue (Interview 4).

3.2.5. Component reuse as a business

According to several interviewees, only certain types of white goods may be suitable for spare parts harvesting (Interviews 1, 2, 4 & 5). Some interviewees talked about the quality of the original product as a determining factor for reusability (Interviews 1, 2 & 5), with one interviewee stating that reused components need to have long lifetimes and large associated production costs to compete with newly manufactured parts (Interview 1). However, cheaper spare parts like shelves or plastic details can be

profitable to harvest for products that are in high demand, as these parts are hard to find elsewhere (Interview 2 & 5). One interviewee claimed that they harvest all kinds of parts as long as they are intact, stating that customers buy everything—even things like screws (Interview 7). Availability of large volumes of used goods was highlighted as an important factor by another interviewee, who said that there must be a large enough base of any given appliance in the waste stream for those appliances and their parts to become economically viable to reuse (Interview 4).

Regarding the availability of reusable goods, one interviewee said that their access to harvestable goods have been diminished recently due to OEMs starting to take back their own used products, suggesting that this is because the OEMs do not want to support the second-use market. The interviewee proposed that access to used products should be regulated and limited to approved reuse companies (Interview 7). On the other hand, another interviewee suggested that a way to reduce the overall costs of reuse practices could be to rely more heavily on the OEMs, since they already possess the technical and logistical means to retrieve and dismantle their own products. This way, reuse organizations could act more like intermediaries between the customer and manufacturer, identifying reusable or harvestable products in exchange for a percentage of the profits. Having the OEM perform this service could also be reassuring for the customer, possibly increasing the selling value of reused appliances and parts (Interview 4).

Several interviewees brought up the leasing business model, or appliance as a service, as a good driver for reuse (Interviews 1, 2, 5 & 6). Some interviewees explained that when selling services rather than products the maintenance costs fall on the supplier, generating a self-interest in providing products with long lifetimes and high reparability. Under this model, reusing components can be a good way for the supplier to guarantee continued functionality at a low cost (Interviews 1, 5 & 6). According to one interviewee, consumers are also more likely to accept the use of reused components when they know that the service provider is responsible for the continued functionality of the appliance (Interview 1). One interviewee said that they are currently in the process of implementing a project to test this business model for white goods (Interview 6).

3.2.6. Future outlook

On the future of component reuse for white goods, most interviewees expressed a positive outlook (Interviews 1, 2, 5, 6 & 7). One interviewee opted to answer evasively, saying that future development largely depends on political and financial factors (Interview 4). Only one interviewee said that they saw no future in reusing spare parts for white goods (Interview 3).

Regarding policy development, one interviewee stated that many are already aware that the producer responsibility needs to adapt to promote reuse over recycling, and that policies are already developing in this direction (Interview 1). Two interviewees said that the Ecodesign Directive will promote the reuse of components by making it easier for repairers to access technical information on appliances

(Interview 1 & 6). However, one interviewee warned that the low bar for entering the repair business may result in an increase of low-quality repairs, suggesting that some regulation may be necessary to counter this (Interview 6). One interviewee said that the new EU legislation concerning spare parts availability is good, but that something more is required. They specifically mentioned that preventing OEMs from limiting reuse organizations' access to used goods is important (Interview 7).

When it comes to consumer attitudes, one interviewee said that they are changing in favor of reuse but that the process is very slow (Interview 2). However, another interviewee said that consumers are already very enthusiastic about reuse and attributes their increased sales of reused goods to this fact (Interview 7).

One interviewee said that there is currently little progress being made with regards to product design and that most companies first want to ensure that the reuse business model is economically viable (Interview 1). Another interviewee expressed doubts regarding the effectiveness of EU law when it comes to product design, stating that not all manufacturers reside in Europe. However, they also said that there is a growing worldwide concern for resource scarcity (Interview 2). One interviewee suggested that the tendency for electronics to become smaller over time could actually improve the accessibility of components for products like white goods, where the overall size of the appliance is usually fixed (Interview 1).

Many interviewees referenced spare parts harvesting for white goods as an active and/or growing business practice (Interviews 1, 2, 5, 6 & 7). One interviewee said that their company harvests spare parts from white goods all the time and sell them for a tenth of the price of new parts (Interview 7). Another interviewee referenced a company in Sweden selling used parts and hinted toward smaller projects that are currently in development. They also indicated that there has been interest from municipalities and other actors on the subject (Interview 2). One interviewee claimed that several established recycling organizations want to expand their practices to include reuse and remanufacturing (Interview 1). This is true for producers as well, according to one interviewee from a PRO who said that producers are lining up behind their reuse initiatives (Interview 5). Another interviewee, representing a large OEM, described ongoing plans to harvest and reuse spare parts, adding that they would also be interested in buying reused spare parts if a serious supplier appeared. They also said that they are eagerly awaiting new policy to push reuse further (Interview 6). One interviewee said that they are not currently working with reused spare parts for their repair service and that they are unlikely to do so in the future (Interview 3).

3.3. Results summary

The main drivers, barriers and suggested actions identified in the literature review and interview study are summarized in Table 3.

Table 3

The main drivers, barriers, and suggested actions to promote reuse of white goods components from the literature review and interview study.

DRIVERS AND BARRIERS	SUGGESTED ACTIONS
White goods entering the EPR system are difficult to reuse	<ul style="list-style-type: none"> Transition to an IPR system where producers are financially responsible for the waste generated by their products Collect reusable goods before they enter the waste stream, for example by establishing local reuse centers
Current policies incentivize recycling over reuse	<ul style="list-style-type: none"> Implement mandatory reuse targets
Consumer demand is mainly driven by economic factors	<ul style="list-style-type: none"> Sell repair with reused parts as a cheaper alternative Use a fixed price repair model
<ul style="list-style-type: none"> Consumers are concerned about the quality of reused items There is a risk for low quality repairs 	<ul style="list-style-type: none"> Implement a certified quality label and warranties Have OEMs handle the reuse of their products Use a leasing business model, where appliances are owned and maintained by the service provider
<ul style="list-style-type: none"> Products are designed in a way that makes components hard to access Some OEMs do not allow remanufacturing by independent actors 	<ul style="list-style-type: none"> Provide economic incentives for producers to design for reuse by transitioning to an IPR system or by implementing individual fees based on reusability Implement legislation that makes it mandatory for producers to facilitate repair by independent actors
Costs for labor and storage associated with harvesting spare parts are too high	<ul style="list-style-type: none"> Standardize parts across models Focus on fewer product variations with higher quality Open up access to OEMs resources, such as technical information regarding appliances and components Delegate responsibility to OEMs that already have the capacity to retrieve and dismantle their own appliances

4. Discussion

4.1. Policy for reuse

The EPR system was highlighted as a barrier for reusing white goods components by both the literature review and the interview study. Two main reasons were given for why it becomes difficult to reuse appliances or components once they have entered the waste stream: one being legal restrictions on the ability to sell items classified as waste, and another being the rough handling of waste diminishing the quality of the goods. The most commonly suggested solution for this problem was to avoid having reusable goods enter the waste stream, either by transitioning to an IPR system where producers are incentivized to avoid generating waste, or by having reuse organizations identify and collect reusable goods before they are discarded. One way this could be accomplished is by having PROs establish local reuse centers.

Another big issue related to policy was that there are stronger incentives for recycling than for reuse. This was brought up in both the literature and interviews, with the interviews emphasizing the lack of mandatory reuse targets as an underlying problem. Because PROs have an obligation to make sure that certain recycling quotas are met, they are incentivized to promote recycling over reuse. While there were conflicting statements regarding the extent of this problem—one interviewee claimed that reuse practices actively subtract from the recycling quota while another claimed that they do not—reuse targets were generally seen as an effective way to promote the reuse of white goods and components.

Interviewees seemed to agree that policy is heading in the right direction, with many seeing the Ecodesign Directive and other EU law as a driving force for reuse and component harvesting. The practice of harvesting spare parts is still in its infancy, and future development will likely expose new possible areas of improvement with regards to policy. As reuse and component harvesting becomes more widely adopted as a business practice, policy makers should keep an eye on how these businesses are conducted to ensure that they are properly aligned with the goals of CE. Specifically, making sure that reusable white goods are placed in the hands of certified reuse organizations or approved remanufacturers should be a priority. Policy makers should also carefully consider how incentives for reuse are affected by tangential legislations, such as recycling quotas or taxes on remanufacturing and repair practices.

4.2. Getting consumers on board

Consumer demand was identified as a very important driver for reuse in the literature review and interview study, with economic incentives being viewed as important for the consumer's decision to repair and reuse. It was unclear in the literature whether the cost of repair is a determining factor or whether the pricing of new products is more important. However, the interviews suggested that lower repair costs would be a major driver for the consumer and that reused parts can provide that. A fixed price repair model was suggested as an effective way to increase consumer demand, by eliminating uncertainty regarding the costs of repair. This could also incentivize the reuse of spare parts through the prospect of lowering repair costs for either the service provider or the consumer, depending on how the business model is set up.

Consumers being concerned about the quality of reused goods was identified as a barrier in both the literature and interviews. The most suggested solution was to implement some sort of quality label or warranties for reused appliances and parts. Consumers were also said to be more willing to trust reused goods when supplied by the original manufacturer. A system where reused parts are harvested and sold by the OEM could therefore be beneficial. Another suggestion from the interviews was to use a leasing business model where the service provider owns the appliances and takes responsibility for its continued functionality.

While there is little doubt that consumer attitudes are changing in favor of reuse, whether these attitudes are currently driving reuse practices is not as clear. One interviewee working directly with selling harvested parts claimed that consumers are overwhelmingly driven by environmentally conscious attitudes. However, there is probably a selection bias here—given that these consumers have purposefully sought out a reused goods vendor—so this likely represents the exception rather than the rule. To increase consumer demand for reused goods and components, pushing them as an economical, green alternative is essential. Policy makers and suppliers should consider quality assurance for reused parts, whether it comes in the form of quality labels or warranties, as a good way to increase demand. Suppliers and service providers should also consider the power of alternative business models like fixed price repair or leasing.

4.3. Engaging producers

The literature review and interview study both suggested that product design hinders reuse practices by limiting access to components. A suggested solution in the literature was to implement an IPR system or having individual fees for producers based on the reusability of their products, to provide economic incentives for producers to design for reuse. The interviews leaned more toward direct legislation, such as making it mandatory for companies to facilitate repair by independent actors.

The sheer variability of products and components was brought up in the interviews as a big challenge for reuse organizations, making it much more costly to

store and catalogue reused spare parts. Some sort of standardization for parts or a focus on fewer models with higher quality was suggested as possible solutions. Both the literature review and interview study suggested that producers could also decrease the costs involved with spare part harvesting by providing access to technical information regarding appliances and their components to reuse organizations. Delegating some responsibility to OEMs may be a more economically efficient way to handle component harvesting, due to the technical expertise and logistical capacity they already possess.

The potential benefits from engaging producers in reuse are many. A system where OEMs are responsible for the reuse and harvesting of components promises to not only incentivize reuse-friendly product design but also lessen the economic burden on reuse organizations, ease consumers' concerns regarding the quality of reused appliances and parts, and avoid losses associated with waste transport. Results from the interview study indicate that an interest in reuse and component harvesting already exists among producers. However, for producers to engage there must also be strong initiatives in place—financial or legislative.

4.4. Ethical reflection

When conducting interviews there are several important aspects to keep in mind from an ethical perspective. Firstly, the personal integrity of the interviewees must be considered. For this reason, interviewees were informed regarding the purpose of the study beforehand and their consent was secured for any recordings made during the conversation. Secondly, personal information belonging to the interviewees must be protected. As the study was anonymous, interviewees were informed about this fact beforehand. The interviewees' names, contact information, and business associations were strictly used for the purpose of conducting the interview and thereafter completely omitted from the research process. Furthermore, all such information was stored securely and privately. As this study relates to business practices—and sometimes personal practices—influencing the environment, which could be viewed as sensitive topics, efforts were made to ensure that interviewees did not feel accused or were otherwise offended by the content of the interview.

5. Conclusion

The purpose of this study has been to identify drivers and barriers for the reuse of white goods components and to determine the future outlook of industry stakeholders. The results have shown that there are several obstacles for harvesting spare parts, some of which are specific for components and some which are related to broader challenges with reuse. Certain barriers stem from an unbalance between recycling and reuse incentives in EU legislation, while others exist due to consumer attitudes, logistical challenges and market-related forces. Many barriers are multi-faceted and influenced by a variety of factors, which makes unravelling them all the more difficult. However, this has not prevented interviewees from conveying a predominantly optimistic outlook on the future of harvesting white goods components. This outlook has been attributed to the arrival of new EU legislation, new business opportunities and increasing interest from consumers, municipalities, recycling organizations and producers. To ensure that this trend continues, policy- and decision makers should consider the following actions:

- Prevent reusable white goods from entering the waste stream by transitioning to an IPR system or by establishing local reuse centers
- Implement mandatory reuse targets
- Introduce quality labels for reused appliances and parts
- Promote reuse-friendly business models, such as fixed price repair or leasing
- Produce appliances with standardized parts, or with fewer models and higher quality
- Incentivize OEMs to engage in harvesting spare parts

To build on the findings of this study, further investigation into the practical implementation of these strategies would be valuable. Questions remain regarding how to effectively implement quality assurance strategies, promote reuse-friendly business strategies, and incentivize producers to engage with reuse. Furthermore, there are undoubtedly more drivers and barriers for the reuse of spare parts left to uncover, and more will likely surface as the business practice continues to grow and develop.

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Appendices

Interview guide

Business model

- You work with reuse of white goods. Do you harvest parts from products that are not being reused?

Alternative questions for PROs/researchers:

- Are you involved in initiatives regarding reuse of components or products?
- Are you selling components or spare parts from your material streams?
- Have you conducted any studies on the potential for re-using parts and components?

- What is the state of the products the parts are salvaged from?
- How do you decide which parts to salvage?
- How do you secure the quality of the parts?
- Are you using the parts in your own repairs/manufacturing or are they being sold?
- Do you also buy new or used spare parts from other actors? If not, would you like to?

General drivers and barriers

- What factors are key to the business model of harvesting spare parts?
- What are the key drivers to developing this business model?
- What are the key barriers to developing this business model?
- How do you see this business model developing in the future? Will there be a focus on products or spare parts?

Policy

- Do you encounter any legal issues when reusing spare parts?
- Under the Ecodesign Directive, there are new regulations that aim to increase the reparability of white goods: do you think this will affect the economic potential for spare parts reuse?
- Regarding current producer responsibility legislation: is there a risk that current targets related only to recycling, and not reuse, can lead to a situation where parts that can be reused instead go to recycling?
- What would you change about current policies to increase the reuse of spare parts?
- Do you think new policy generally benefits or hinders the reuse of spare parts?

Consumer attitudes

- What are the most common questions you get from consumers regarding reused parts?
- Have you noticed if consumer attitudes toward reused parts are changing? If so, how?

Product design

- Is there any difference between older and newer products in terms of harvestability of components?
- Do you see any general trends regarding new product designs?

Additional interviewees

- Do you know someone else that would be suitable to interview on this subject?



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