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Abstract

The rapid growth in consumption and use of electronics has resulted in E-waste becoming one of the most accelerated global waste streams. Despite high rates of electrical and electronic (EE) recycling, Norway is one of the countries with the highest generation of E-waste per capita. Inspired by circular economy principles and previous research on the E-waste stream, this thesis explores the potential for reuse in solving the waste problem in the Norwegian EE industry. As reuse of EE products remains low in Norway, this thesis examines the current state of the industry and identifies barriers to reuse adoption. This is supported by insights from four semi-structured expert interviews and secondary data. The findings suggest that the most prevalent barriers are the linear design of products, economic unsustainability, consumer scepticism, lack of clear regulations and product value loss due to irresponsible treatment. Recommendations are presented as guidance on how to overcome these barriers and accelerate the reuse rate in Norway. This has important implications for policymakers and industry stakeholders that wish to transform their industry and business models. The barriers apply across stakeholder groups and require an industry-wide understanding of how to establish effective collaboration and ultimately increase the reuse of EE products.

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Figures and Tables

Abbreviations

B2B	-	Business-to-Business
B2C	-	Business-to-Consumer
CBM	-	Circular business model
CE	-	Circular Economy
CEAP	-	Circular Economy Action Plan
EEA	-	European Economic Area
EEE	-	Electrical and Electronic Equipment
ERP	-	Extended Producer Responsibility
GHG	-	Greenhouse gasses
ICT	-	Information and Communications Technology
SDG	-	Sustainable Development Goals
VAT	-	Value-added-tax
WEEE	-	Waste Electronic and Electrical Equipment (E-waste)

1. Introduction

Despite decades of dire warnings from scholars, the recent IPCC AR6 discloses that human influence has unequivocally warmed and altered the Earth system (The Intergovernmental Panel on Climate Change [IPCC], 2022b). This is largely driven by unsustainable production and consumption patterns, resulting in increased emissions of greenhouse gases (GHGs) and environmental degradation (IPCC, 2022b). Even though global climate change amplifies environmental degradation, this thesis highlights the effect of land-use change and intensive industry on environmental integrity. A prevalent driver is the excessive extraction of minerals (Jacka, 2018). This thesis underlines its interconnection with high consumption and waste society, more specifically in the electrical and electronic (EE) industry.

The challenge of the extractive industry of mineral resources is a multi-dimensional issue influenced by poor governance and regulation, informal and exploitative work conditions, and a lack of environmental cost internalisation (Hirons, 2011; Humphreys, 2001). Yet, this thesis argues that the underlying driver is the linear consumption-to-waste practice in the use of electrical and electronic equipment (EEE). This is supported by scholarship (Bachér, et al., 2020). The European Union (EU) denotes the stream of EEE as one of the most rapidly growing challenges due to higher consumption and waste, and consequently a barrier to a sustainable future (European Commission, 2020a). One country which stands out in rapid and high EEE consumption and waste is Norway.

According to the Norwegian Ministry of Environment, the average per capita E-waste in 2020 equalled 26kg (Miljødirektoratet, 2021a). This constitutes more than 3 times the global per capita average, given the 7.3kg estimates from 2019 (Forti, Baldé, & Kueh, 2020). It is further argued that the drivers behind the world's fastest-growing waste stream, namely the trend of discarded EEE, are due to technological advancements, short life cycles, high consumption rates, and limited repair options (Forti, et al., 2020). It follows that global demand for natural resources is increasing, and concerns regarding the supply of critical raw materials have arisen (Bachér, et al., 2020). In the Norwegian context, this is clear by examining the record-breaking sales in the Norwegian EE industry where revenues exceeded 43,6 million NOK in 2021 (Ottemo, 2022). This is influenced by the benefits of connectivity from smartphones, laptops, and tablets which often seem to be regarded as necessities in day-to-day life. Yet inevitably, it also generates an increasing portion of waste containing precious and hazardous materials (Miljødirektoratet, 2021a). In summary, there is demand for a new way of consumption in which products are processed through collection and recycling channels, ultimately reducing the overall consumption of new products.

Circular design and economy embed such principles and could meet the demand in the market whilst at the same time reducing the environmental impact. In a Circular Economy (CE), the mineral and material resources are kept in a loop by recycling and reuse (Murray, Skene, & Haynes, 2015). The EU´s Circular Economy Action Plan (CEAP), as a part of the Green Deal, focuses on Electronics and ICTs as a priority sector due to their environmental impact and circularity potential. Specific initiatives promoting longer product lifetimes, a right-to-repair, and improved collection and treatment of e-waste highlight the importance of reuse (European Commission, 2020a). The Norwegian government supports the EU's prioritizing of EEE and can refer to efficient waste management systems with high collection and recycling rates (Regjeringen, 2021). It is also important to highlight that reuse remains low. For instance, only 2% of the E-waste collected in 2021 was prepared for reuse (Miljødirektoratet, 2022b). Simultaneously, users regularly dispose of usable and repairable items (Bergensområdets Interkommunale Renovasjonsselskap, 2021). Therefore, this thesis deems it particularly important to focus solely on the reuse aspect of CE.

The potential of reuse is evident, yet not fully examined nor exploited. There is previous research on the reuse of EEE but quite little is applied to a Norwegian context. Furthermore, both global and national devotion toward CE stresses the need for additional research on sustainable production and consumption. As a result, this thesis complements current research while acting as a supplement to the Norwegian government's CE strategy. Moreover, it intends to briefly examine feasible reuse methods in the Norwegian context and highlight some of its barriers.

1.1 Research Objective and Questions

This thesis aims to provide a comprehensive assessment of barriers to EEE reuse, specific to a Norwegian context. The research objective in hand reads:

> What is required for the Norwegian EE industry to overcome barriers to reuse?

By drawing on insights from key-informant interviews, the analysis will address the objective by answering two research questions:

> RQ1: What is the status quo in terms of EEE reuse in Norway?
> RQ2: What are the barriers to implementing reuse in the value chain of EEE?

Through a comprehensive literature review and collection of stakeholder opinions across the value chain, the thesis examines why reuse remains low in Norway, despite high recycling rates. Thematic analysis is applied to identify barriers to reuse and the results are discussed and connected with key stakeholder groups. Lastly, recommendations on how to accelerate reuse are provided.

1.2 Delimitations and Definitions

The scope of this thesis is limited to the concerns around the reuse of consumer electronics in Norway. The term consumer electronics refers to a range of EEE such as smartphones, computers, televisions, and home appliances intended for personal/non-commercial use. The EE industry refers to enterprises that handle EEE. This includes suppliers, wholesalers, chains, retailers, and workshops whose core activities involve design, manufacturing, assembling, sales, and services. In addition, the end-of-life management of EEE, namely waste management, is included in the analysis of the EE industry. Furthermore, the thesis refers to the definition of reuse by Eurostat, i.e., “any operation by which products or components that are not waste are used again for the same purpose for which they were conceived” (Eurostat, 2019).

The primary data source for this thesis is interview responses from stakeholders in the Norwegian EE industry. This includes individuals representing enterprises and organisations whose primary activities involve the handling of EEE through sales, maintenance, reuse, or waste management. More specifically, four stakeholders have been included: (i) a consumer electronics retailer, (ii) an approval scheme for the reuse of consumer electronics, (iii) a WEEE compliance scheme, and (iv) a waste management and recycling association. The interviews were conducted to explore the value chain in a Norwegian context, rather than a detailed investigation of upstream production. This is an important note as most EEE has been produced abroad (Nørstebø, et al., 2020). Even though manufacturers are excluded from the sample, production aspects are covered to some extent in the analysis. Moreover, due to time and resource constraints, consumer insights will not be collected and expert opinions were preferred.

1.3 Thesis structure

The thesis is structured as follows. Chapter 2 is a brief literature review on reuse. Chapter 3 introduces the theoretical background, therein an examination of SDGs and Circular Economy’s relevance in examining reuse and business models. Chapter 4 explains the process of data collection. Thereafter, Chapter 5 highlights the methodology of this thesis. This chapter covers the research design, method of analysis, and an evaluation of the trustworthiness of the study. Chapter 6 presents and discusses the results of the study. This is divided into three main sections: (i) the status quo of the Norwegian EE industry regarding operational details and reuse commitment, (ii) identified barriers to reuse and (iii) key recommendations for how the industry can engage in a circular transformation around reuse. Lastly, in Chapter 7, a conclusion is provided.

Figure 1: Thesis structure

2. Literature Review: Reuse of EEE

Before presenting the theoretical background and circular business models that foster reuse, it is necessary to understand the context of reuse in literature. This chapter briefly reviews the findings of previous literature on the reuse of EEE. Note that the findings presented include academic literature and reports, wherein it mostly focuses on studies in other countries.

The reuse of EE products involves multifarious activities. For instance, direct reuse might involve a transfer by giving or selling a product to a second owner (Read, Gregory, & Phillips, 2009), sharing or leasing (Bocken, Short, Rana, & Evans, 2014), or trade-in services. These methods are defined as citizen reuse (Electronic Reuse Federation, n.d.). All these methods take place before the product becomes waste. Moreover, reuse also involves the discarded product. This can occur either in refurbishment or repair form or in the reuse of materials (Cole & Gnanapragasam, 2017). The first involves the repair of a broken or discarded product (e.g., a smartphone). The second involves the reuse of materials interconnected with recycling wherein a product is dismantled, and intact materials are reused in the production of a new product (Bartl, 2014). Yet, these activities of reuse differ between electrical and electronic product categories.

Various studies (Bovea, Ibáñez-Forés, Pérez-Belis, & Quemades-Beltrán, 2016; Park & Chertow, 2014; Truttman & Rechberger, 2006) highlight the importance to understand the potential for reuse by examining different product categories. For instance, studies emphasise the value of reused IT products such as mobile phones, computers, tablets, and televisions (Benton, Coats, & Hazell, 2015; Wieser & Tröger, 2018). The second-hand market for this product category is trending, both for private consumers and companies (Gregson, Crang, Laws, Fleetwood, & Holmes, 2013). Moreover, the market for the white goods product category (including products such as refrigerators, washing machines, dryers, dishwashers, and stoves) appears to supply good-quality products in second-hand markets, often leading to high purchasing prices (Pérez-Belis, Bovea, & Ibáñez-Forés, 2014). Lastly, the potential for reuse of minor household goods is poor due to their low product value and high repair costs. Products such as blenders and toasters are often disposed of rather than recycled, sold, or repaired (Darby & Obara, 2005). Hence, it is essential in this study to examine the product categories' potential for reuse, as well as the overall determinants for reuse opportunities.

As indicated, it is important to examine the overall determinants for reuse potential. This review highlights three additional considerations, namely consumer willingness, quality standards, and legislation. Firstly, according to Bridgens et al. (2017), an important determinant for the successful reuse of mobile phones is the willingness and participation of consumers in the value chain. Whilst they focus on the integration of emotional 'bonds' with the consumers, it draws on the principle of individual responsibility. Individual responsibility can both incentivise manufacturing changes as well as induce market emergence for second-hand markets (Atasu & Subramanian, 2012). Moreover, findings show that in the UK individuals might be willing to donate products for reuse but have a higher reluctance to purchase such products (Cole, Cooper, Gnanapragasam, & Singh, 2019a). This challenge, i.e., customer acceptance (Weelden, Mugge, & Bakker, 2016) also depends on the ability of consumers to rely on products that have been used or repaired. Second-hand products have a higher risk of having poor durability, which indicates that they might not withstand long-term usage (Velden, 2021). This ultimately connects with the quality standards of products.

The second consideration for reuse potential is quality standards. For instance, once a product becomes waste, the risk of value loss gets significantly higher (Benton, et al., 2015). A disposed product needs to be prepared for reuse to maintain its value. This can include activities such as cleaning, repairing, or safety testing (Cole, et al., 2019a; Messman, Boldoczki, Thorenz, & Tuma, 2019). Furthermore, literature often grades quality levels by considering the overall condition and emphasises that by grading products one can consider whether the product is feasible for reuse or not (Messman, et al., 2019).

The last consideration to highlight is the influence of national and international legislation. The latter can cover international legislation such as the EU's WEEE Directive (Directive 2012/19/EU) and the Eco-design Directive (Directive 2009/125/EC). It can also be influenced by aggregate frameworks such as the United Nations Sustainable Development Goals (SDGs), international strategies such as the CEAP (European Commission, 2020a), and international conventions such as the Basel Convention (United Nations Environment Programme, 1989). On a national level, the Norwegian Circular Economy Strategy (Regjeringen, 2021) is of importance, as well as the national waste regulations (Avfallsforskriften, 2004). Both of which aim to contribute to reuse by reducing waste and introducing circular principles.

The increasing awareness and focus on circular principles (Cole, et al., 2019a), therein circular economy, is a result of decades of growth in EEE consumption and E-waste. As mentioned in the introduction, the increase in consumption of EEE and the development of new technology have resulted in fast-growing waste streams both in volume and complexity. This necessitates proper waste management in all countries (Forti, et al., 2020). Several solutions are highlighted in the literature, including producer responsibility (Favot, Grassetti, Massarutto, Antonio, & Veit, 2022), change of business models (Cherry & Pidgeon, 2018; Cole, Cooper, Gnanapragasam, & Singh, 2019b), take-back schemes (Cole, et al., 2019b; Wang, et al., 2022), design for longevity (Lewandowski, 2016), and increased warranty for new and repaired products (Cole, et al., 2019b). Moreover, and as this section has shown, the determinants of reuse potential are multi-dimensional, and thus one should consider the micro-, meso-, and macro-level factors (Kirchherr, Reike, & Hekkert, 2017).

Before this thesis moves on to explore the theoretical background, it is essential to highlight that there is limited research on EEE reuse in the Norwegian context. A few studies have explored waste management practices (Høglo, 2016; Stensgård, 2014), while research on reuse is mainly associated with the construction industry (Moum, Skaar, & Midthun, 2017; Nappe, 2021) and plastic materials (Dammas, Lund, Kenzhegaliyeva, Lindberg, & Ullern, 2022; Sørumsbrenden, 2019). Note that there is previous research of relevance to this thesis, conducted by (Abbas & Vølstad, 2017). Yet, this research examines the opportunities for a circular business model (CBM) and product design rather than mapping specific barriers and opportunities for reuse. Moreover, a report of interest was developed by Cowi and Avfall Norge where a detailed framework is presented to support municipalities in developing local solutions for the reuse of the EEE (Kofstad, Kaspersen, & Bäcker, 2019). This will be referenced throughout this thesis.

3. Theoretical Background

This chapter presents the theoretical background behind the thesis and its analysis. It draws on CE principles and examines the integral role of reuse in a CE. Moreover, the chapter introduces circular business models to contextualise the potential of reuse. This is particularly important for understanding the discussion and recommendations in Chapter 6. Yet, before the focus on CE, it is essential to gain an understanding of which SDGs are relevant and build the foundation for reuse's role in sustainable strategies.

3.1 UNs Sustainable Development Goals

Climate change caused by human activities is one of the major divisive issues that the global community faces today (IPCC, 2022a). Increasing temperatures are largely caused by the extraction and use of fossil fuels in the electricity, transport, and industrial processes. Moreover, additional interconnected concerns such as high and unsustainable consumption in Global North countries, poor living conditions in many Global South countries, and global inequality weakens the probability of collective and equal development (European Commission, 2020b; Jalota, Vashisht, Sharma, & Kaur, 2018). Thus, there is a need for a collective framework, with common goals, aiming to require action for a more sustainable future. A prominent example, which has been adopted widely amongst governments, multinational companies, and civil society, is the United Nations (UN) Sustainable Development Goals.

The UN's SDGs were first adopted by the UN General Assembly in 2015, setting the premise for a holistic and interconnected mindset on how to tackle issues such as poverty, climate change, and other aspects of social development (Nilsson, Griggs, & Visbeck, 2016). It defines 17 overarching targets (i.e., the SGDs) with 169 sub-goals. Moreover, the UN is "determined to take the bold and transformative steps which are urgently needed to shift the world onto a sustainable and resilient path" (United Nations, 2015). It is thus implicit that the purpose is to both benefit people and the environment by emphasising the interconnectivity and dependence between the SDGs (Nilsson, et al., 2016). In the context of reuse in the EE industry, it is important to highlight the interdependence of SDGs as well as the context in which they are likely to be solved (e.g., globally and nationally). Note that it is assumed that the actual implementation necessitates collaboration between governments, companies, and civil society (United Nations, 2015).

The adoption of the SDGs in the EE industry shows both direct and indirect links of impact and importance. Therein, it is salient to account for the difference between Norwegian versus non-Norwegian influence (see *Figure 2*). Hence, this thesis includes the key relevant goals as follows: SDG12 – Responsible Consumption and Production, SDG11 – Sustainable Cities and Communities, SDG9 – Industry Innovation and Infrastructure, and SDG8 – Decent Work and Economic Growth. These goals reflect categories of environment, climate impact and use of resources as central for the EE industry. Other interconnected SDGs (7, 13, and 15) are also highlighted in *Figure 2* to show the complexity of the EE industry. Yet, these will not be discussed further as they cannot be denoted as specific for the reuse of EEE in Norway, but rather wider systemic goals.

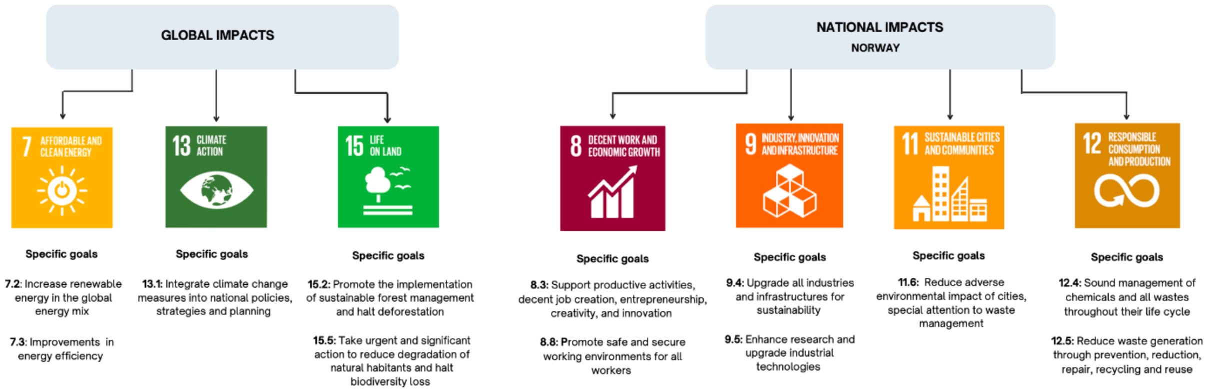

Figure 2: The seven most relevant SDGs for the electronic industry
Selection inspired by (United Nations, 2018; Moldskred & Skarbø, 2020)

As illustrated in *Figure 2*, there are multiple ways in which the SDGs interconnect with the EE industry. For instance, SDG8 emphasises the need for new job creation and innovation, wherein innovation of reuse practices could be a possible solution. This is further specified by the SDG9 with industry-wide innovation. Moreover, SDG11 specifically highlights waste management (e.g., E-waste) as a milestone for reduced environmental impact in cities and communities. Yet, the most relevant to bring attention to is the SDG12, which aims to reduce waste and empower sound management in product life cycles. It follows and is specified, that reuse is an essential component to attain this goal.

Reducing E-waste through reuse interconnects with other SDGs, such as reduced land degradation and biodiversity loss, creating jobs, and involves both innovation and improvements for sustainable infrastructure and technology. However, the SDGs only specify the end goals and thus the process or mechanism by which success will be achieved remains unclear. On that account, one possible pathway for implementation is a circular economy.

3.2 Circular Economy

Before the circular economy concept is explained, it is necessary to understand that the current economy is perceived as linear. Materials are extracted from the earth, used in production, and disposed of after use, thus leading to an unsustainable linear model (Korhonen, Honkasalo, & Seppälä, 2018). The economy's linear model is pressuring Earth's resources and natural thresholds, wherein our high extraction and consumption levels are threatening the availability of resources for future generations (Luthra, Manlga, Sarkis, & Tseng, 2022). Thus, it is critical to understand and challenge the status quo by ensuring that the economy can keep using the materials that have already been extracted, for instance in a cycle of reuse.

The integration of a *cycle* is most associated with Circular Economy (CE) which has become a popular concept both in academic literature and corporate strategies. Consequently, various definitions have emerged (Lacy, et al., 2015), yet there is much ambiguity and no set definition. For instance, Kirchherr et al. (2017) analysed 114 definitions of CE. In their analysis, it appears to be some recurring features such as the use of different '*Rs'*, namely *redesign, reduce, reuse, refurbish, repair, repurpose, recycle,* and *recover*, whereas the terms *reduce*, *reuse,* and *recycle* are most frequently repeated (Kirchherr, et al., 2017). Even though the definitions differ in agreement, they share the same core idea of a circular economy: a system of closed flows of materials and energy (Murray, et al., 2015). Hence, instead of attempting to adopt a unified definition, this thesis presents key guiding principles for understanding the importance of reuse in the EE industry.

The overarching guiding principle of CE is to keep all products in use for as long as feasible. In other words, keep products and materials in a closed loop. The goal is thus to eliminate waste and minimize pollution (Miljødirektoratet, 2022a). These ideas are derived from nature's circular cycles and imply that all resources have an application. In a perfect circular economy, waste is not produced but rather reused (Nilsen, 2021). See *Figure 3* for a comparison between linear and circular economic models.

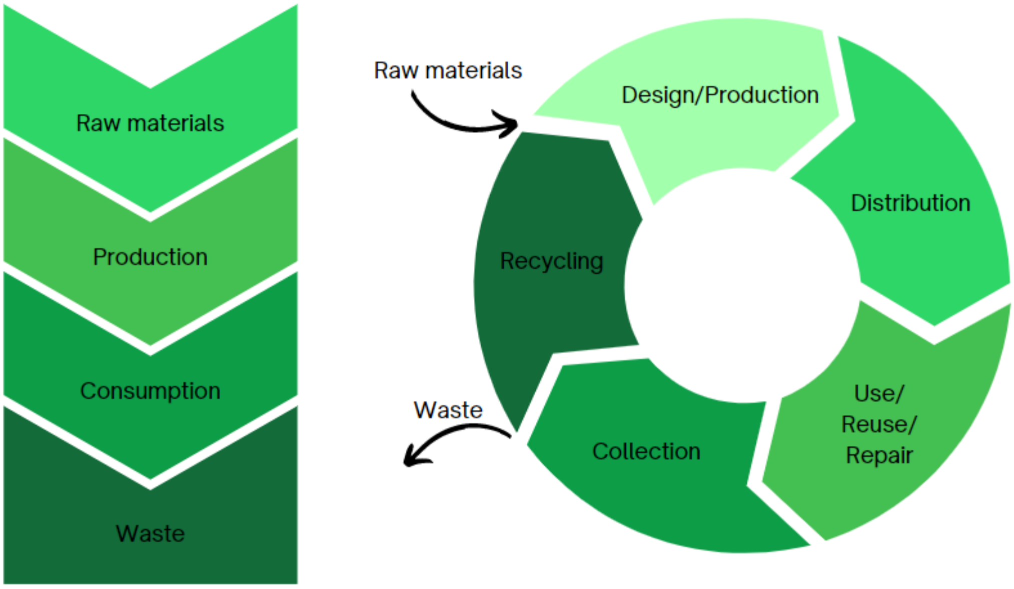

Figure 3: The linear- and circular economic model, created by the researchers Inspired by (Pont, Robles, & Gil, 2019)

Furthermore, the Ellen MacArthur Foundation highlights key principles for CE as a driver for a sustainable transition, therein achieving the SDGs. More specifically, these principles are divided as follows: (i) eliminate waste and pollution, (ii) circulation of products and materials, and (iii) regenerating natural systems.

Eliminate Waste and Pollution

The first key principle attempts to tackle the notion of the *take-make-waste* practice, which has a profound influence on the contemporary method of production. Raw materials are extracted, used in products, and discarded as waste (MacArthur, et al., 2015). Hence, the elimination of waste and pollution is the first important step toward a CE. This is initiated at both the design and manufacturing phases of product development. A common conceptual framing of this step is the Cradle-to-Cradle design framework. This is defined as the safe and sustainable design of products, where everything serves as a resource for something else (McDonough & Braungart, 2002). Therefore, manufacturers need to minimise the amount of packaging, prioritise the use of recyclable materials, as well as the notion that waste can be re-innovated into new products (Bridgens, et al., 2017). For instance, E-waste should not be thought of as waste but rather as a component in new product development. Hence, this will be an essential principle for CE integration in the reuse of EEE. Lastly, this first step is particularly important for reducing environmental impact.

For instance, as much as 80% of the environmental impact of a product is determined in the design phase (European Commission, 2020a). These statistics emphasise the importance of *designing out* pollution and waste in the product cycle (Dooley, 2021). In other words, to reduce waste, products need to be created in such a way that they can be reused or recycled easily. Even though this might appear to be unattainable, Ellen MacArthur (2020) emphasises that "there is no waste in nature, it is a concept we have introduced". Hence, this principle also includes a fundamental shift in conceptual understanding wherein specific methods can be adopted.

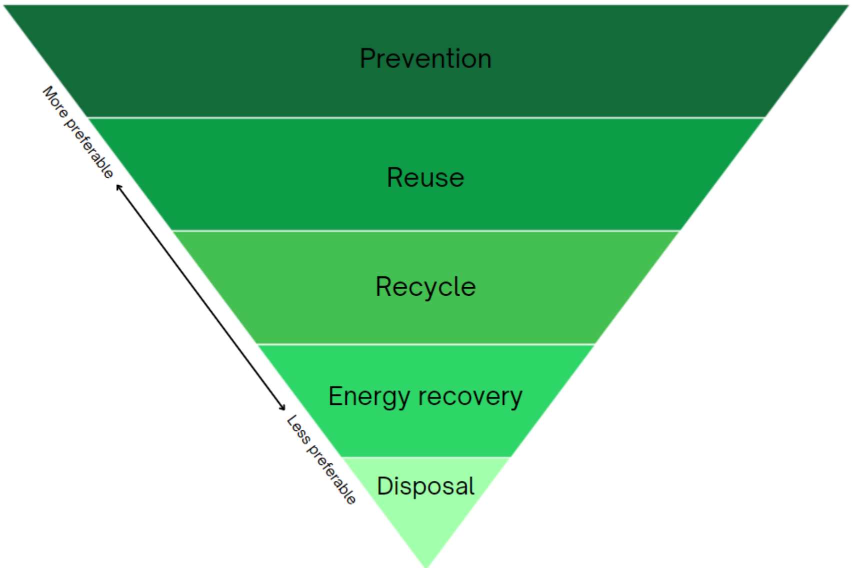

Figure 4: The waste hierarchy created by the researchers
Inspired by (European Commission, 2017)

To highlight the specific method, it is useful to contextualise it with a waste pyramid (*Figure 4*) showing how the different methods of waste management are arranged by priority. Specifically, from highest to lowest priority, waste management can be conducted either by *waste prevention, reuse, recycling of materials, energy recovery,* and at last *disposal*. The highest priority, namely waste prevention, can occur both before and during production. It can be accomplished by employing high-quality materials and designing in a restorative and regenerative manner, reducing the use of packaging, and extending the lifetime of products. The second priority is reuse, which this thesis focuses on, and is implemented after the production (Directive 2008/98/EC). This will be further explored in the next section (3.3). The third priority of recycling is close connected with reuse but is rather adopted if a product is too fragile to be repaired. Hence, materials should be recycled and used as raw materials in other products. This must be established and approved by industrial processes, e.g., waste management facilities (Cole, et al., 2019a) and is thus dependent on robust regulatory practices.

The final two, energy recovery or disposal, encapsulates the final usage of old materials or the decision to conduct disposal (Gregson, et al., 2013). For instance, deteriorated wood and other natural products might be difficult to recycle or reuse, hence the higher priority waste management methods are not applicable. Thus, the final optimalisation would be to either use the stored bioenergy or dispose of the materials altogether. Note that it is important to consider the hazardous impacts on health and the environment when subjecting waste to energy recovery or disposal (NSW Environment Protection Authority, 2017). Yet, the CE captures more than the sole understanding of waste management and minimising waste. It also reflects deeper thinking about circulating products and materials.

Circulate Products and Materials

The second principle of CE covers the understanding that there are two different cycles of products and materials, namely the biological and technical cycles. The biological cycles consist of renewable resources such as plants and animals, all of which are extracted from the Earth's system. Moreover, in a CE, such resources should be returned to the natural system through processes such as composting. It is through these processes that the resources can truly be circular and once again give life to new biological resources (Ellen MacArthur Foundation, 2020). Yet, in this thesis and with the topic of the EE industry, this cycle will not be remarked on further. On the contrary, the technical cycles will be key in understanding the potential for reuse in Norway.

The technical cycles include finite materials that can be reused, such as metals and plastic in the EE industry. As emphasised above, products should be reused first, as this is the second priority in the waste hierarchy as well as this is the method in which most value of the resources is contained. Specific solutions include sharing, leasing, or resale (Lacy, et al., 2015). Thus, measures such as maintenance, repair, and refurbishment are also essential for keeping the product quality at a level where it is accepted by consumers (Weelden, et al., 2016). Moreover, when a product reaches the end of its lifetime, it should be recycled wherein different components and materials can be reused in new products. It thus follows that reuse and recycling overlap in their technical cycle and utility for waste management. Overall, by implementing reuse and recycling, the goal is to minimize systematic leakage and negative externalities (MacArthur, et al., 2015). The process of the technical cycle is presented in *Figure 5* and displays the notion that interconnected thinking of the system-loop around EE products is essential. Note that the sole systematic leakage only occurs if the quality of products after collection is not sufficient for recontinuation in the loop.

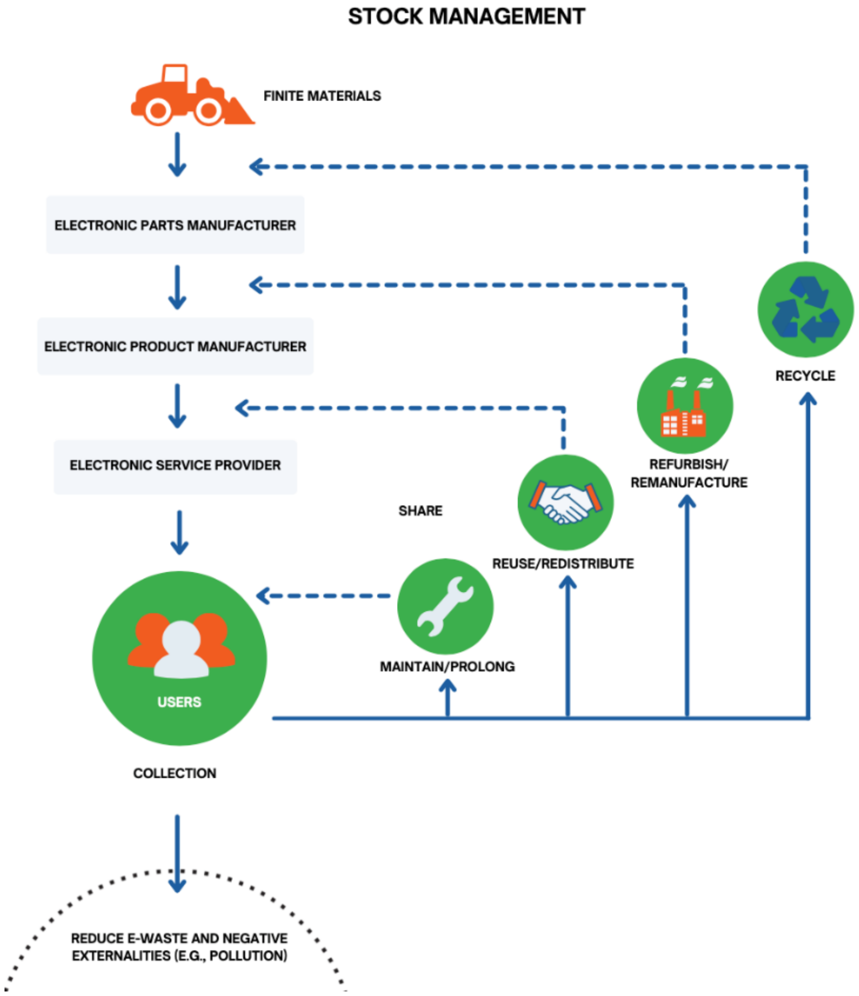

Figure 5: The Circular Economy System adopted to EEE
Inspired by (Ellen MacArthur Foundation, 2019)

Regenerating Natural Systems

The last principle in CE is to regenerate natural systems. This involves the shift away from a take-make-waste linear economy toward the rebuilding of nature (Ellen MacArthur Foundation, 2020). In other words, this principle aims to develop a model of extraction into a model of regeneration. Yet, the idea has thus far mostly been employed in farming practices to restore soil quality, boost biodiversity, and return biological materials to the Earth system (Fullerton, 2015). Nonetheless, it is important to consider if practices of regenerative design can be adopted in other industries such as EE. This can entail a replication of natural systems in the handling of EE products, thus eliminating waste. Further examination of this is not in scope in this thesis as it mainly tackles the technical cycle of EE products.

Yet, it is important to note the condition of keeping the extracted materials within the loop. This should ultimately result in lower extraction of new resources. Hence, this principle in CE can ensure a gradual decrease in extraction rates and thus more land can be recovered, protected, and restored to its natural state (Velenturf & Purnell, 2021).

3.3 Circular Business Models

Given the previous discussion on CE, this section applies the CE principles to understand how reuse may be implemented in business models. Its contribution to this thesis is acknowledged and drawn upon in the discussion of results from stakeholder interviews and the implications of these findings (Chapter 6). Additionally, this section highlights five circular business models (CBM), namely circular supplies, resource recovery, product life extension, sharing platforms, and product as a service.

Before the specific business models are explained, it is important to define what it constitutes. Business models can be defined as “structural templates of how companies run and develop their businesses at holistic and system levels” (Antikainen, Aminoff, Paloheimo, & Kettunen, 2017). That is, a business model framework should explain how an organisation generates, distributes, and captures value (Osterwalder & Pigneur, 2010). A study conducted by IBM shows that financially successful companies value business model innovation twice as much as less financially successful companies (2007). Hence, business models represent an essential component in integrating new forms of economic thinking, such as CE principles.

Various inquiries support that business models are one of the most influential features of the transition to a CE (European Commission, 2015; Lacy, et al., 2015; Murray, Skene, & Haynes, 2015). A circular business model describes how a company captures value for itself and the customer, while simultaneously eliminating or reducing waste in its design by enabling disassembly, repairability, and the use of renewable energy (Vermunt, Negro, Verweij, Kuppens, & Hekkert, 2019). Moreover, CBMs are an opportunity for organisations to be profitable and sustainable. Yet, the potential of CE opportunities is not fully considered or exploited by conventional companies. Hence, it is even more essential to map different CBMs for inspiration. In 2015, a prominent report presented five business models that together drive the CE transition (Lacy, et al., 2015). The models were identified from an analysis of more than 120 case studies and will be presented in this section. Thus, it is argued that if a company can implement one, or a combination, of these strategies it will contribute to the transformation toward a CE.

Circular Supplies

The first CBM, namely circular supplies, is based on using fully recyclable, renewable, or biodegradable resource input in the production processes. Consequently, this will reduce waste, resource consumption, and non-renewable resource depletion (Gaasbek, 2021). In other words, the goal is to reduce a company's reliance on new materials which supports the principles of waste prevention and regenerating nature by reducing new extraction. Furthermore, companies can benefit financially from reusing materials (Kumar & Putnam, 2008) as the production cost could be lower if manufacturers neglect the cost of extracting virgin materials. The Circular Supplies model is most relevant for companies dealing with scarce commodities and those with a significant environmental footprint (Lacy, et al., 2015). The idea behind the CBM is to keep all materials in loops, as is the core idea for CE.

Resource Recovery

The second CBM, resource recovery, concerns exploiting the value of a product at the end of its lifecycle through the reuse of materials and energy recovery. Accordingly, waste can create value in new products rather than being disposed of and not utilised (Lacy, et al., 2015). For instance, materials can be returned after usage and reused in similar goods, thus eliminating material leakage (Potting, Hekkert, Worrel, & Hanemaaijer, 2017). Moreover, high-quality materials can be repurposed (i.e., used in a new product with a different function) across industries (Morseletto, 2020). The Cradle-to-Cradle design briefly described in section 3.2, will, for instance, present an advantage as the dismantling of products becomes less demanding, which may contribute to preserving the material value.

However, recycling materials is considered one of the least efficient circular strategies. This is mainly because it is difficult to attain the same quality of recycled materials, as virgin materials (Morseletto, 2020). Consequently, most recycling today is downcycling, meaning that the materials lose quality over time (Kirchherr, et al., 2017). This is because upcycling, namely, converting materials to higher quality, is often not deemed possible for products throughout the technical cycle (Morseletto, 2020).

Product Life Extension

The third CBM emphasises the extension of product lifespan by implementing the possibility of reuse by repair, refurbishment, and remanufacturing in the design and manufacturing phase (Morseletto, 2020). In such a CBM, companies create value in extended usage, not volume. For instance, by offering spare parts, software updates, repairs, and other services to their customer (Fontana, et al., 2021; Lacy, et al., 2015). Thus, product properties such as durability, quality, and repairability are highly valued. However, extending a product's lifetime usually requires more resources (Lacy, et al., 2015) which may increase waste (Golsteijn, 2021).

Sharing Platforms

The fourth CBM promotes sharing of goods between individuals or organisations through sharing platforms. This CBM has increased in relevance and potential for adoption due to digitalisation (Lacy, et al., 2015). For instance, customers may utilise sharing platforms to rent or borrow cars, washing machines or clothes (Potting, et al., 2017). Prominent examples in the contemporary market are *Airbnb*, *Ryde*, *Kolombus*, and *Nabohjelp*. Moreover, companies can generate income by charging a fee for the use of the platform and its services (Mieras, 2021). This method of business execution will lengthen the use of each product and decrease the demand for new products (Potting, et al., 2017). Note that consumers selling products between each other are not considered part of a sharing platform, as the CBM does not involve permanent access to products (Potting, et al., 2017). This would rather be captured by the previous CBM, namely Product Life Extension.

Product as a Service

The last CBM covers the notion that consumers reduce their full ownership rights of a product. In other words, instead of purchasing products, consumers use products through leasing or pay-for-use arrangements (Goedkoop, 2021). This CBM promotes durability and upgradeability and is advantageous for companies offering high-quality maintenance and products with a high cost of operation (Lacy, et al., 2015). Moreover, product as a service implies a long-term relationship with customers, wherein customers become a part of the user-centric product development (Vermunt, et al., 2019). The goal is to preserve the value of the product and generate revenue by letting several users utilise it. Thus, companies will have the same products in circularity, which decreases the need for new production and new extraction (Barquet, Gouvea de Oliveira, Amigo, Cunha, & Rozenfeld, 2013).

4. Data collection

To answer the research questions, a variety of sources were used. This chapter elaborates on how and why the thesis' primary and secondary data were collected.

4.1 Semi-structured Interviews

The primary data for this study was collected through semi-structured interviews. The subsequent sections describe the sampling strategy, the creation of an interview guide, and how the interviews were conducted.

4.1.1 Sample Selection

The participants in this study were selected based on relevance and mention in the literature review. More specifically, the selection was conditional on individuals who could affect the EE industry as well as the recovery and treatment of Waste Electrical and Electronic Equipment (WEEE).

The sampling process was initiated with a mapping of the Norwegian value chain in the EE industry. In the search for relevant organisations, their ability to provide valuable insight was evaluated, before shortlisting the sample to a few potential candidates. In addition, the recruitment followed a snowball sampling method, whereby the initial subjects referred the researchers to other potential candidates (Clippinger, 2017). All interviewees were contacted by email, which contained an explanation of the research objectives and an invitation to take part in an online Teams meeting.

In total, four individuals with experience from different parts of the Norwegian value chain were interviewed (see *Table 1* below). The interviewees hold job titles ranging from CEO, CCO, Professional Advisor, and Head of Sustainability. This was deemed important as it could increase the likelihood of gaining extensive insight concerning the reuse of EEE. The identity of the informants was anonymised for the sake of privacy and to ensure that the participants would speak freely without being liable or concerned about their remarks. Consequently, neither enterprises nor the individuals that have contributed with insights are mentioned by name.

Table 1: Overview of Informants

Informant 1	**Informant 2**	**Informant 3**	**Informant 4**
Consumer electronics retailer	Approval scheme for the reuse of consumer electronics	WEEE compliance scheme	Waste management and recycling association

4.1.2 Interview Guide

The purpose of an interview guide in a semi-structured setting is to assist the researcher in addressing topics of interest and to prevent the conversation from veering off track (Arntzen & Tolsby, 2010). The interview guide was prepared in parallel with examining previous research on reuse. This allowed the researchers to discard and edit questions that were previously addressed in the literature. The final revision of the guide (see Appendix A) appears quite extensive. Yet, as the researchers' interview experience was limited, the extensive interview guide acted as a security measure to ensure that the interviews did not result in briefness in the discussions or unclarity in direction.

Subsequently, each interview was structured into a few overarching topics that assisted in steering the conversation. This includes an introduction, the status quo of the industry, general drivers and barriers, consumer behaviour, policy landscape, and a final recap of the interview. As shown in the interview guide, each topic compromises a set of sub-questions that aimed to prompt the vocalisation of the informants' expertise and potentially encourage critical thinking around their understanding of different reuse aspects.

4.1.3 Execution of Interviews

The interview was performed separately with each informant to ensure comfortability and anonymity. Each interview was conducted through Microsoft Teams and lasted around an hour. During the interviews, the two researchers had pre-allocated roles. Herein, one was tasked to ask the questions while the other was tasked to take notes on relevant concepts and contribute with follow-up questions. Furthermore, the interviews were recorded with the consent of each participant.

Each interview started with an informal introduction of the researchers and the purpose of the interview. Thereafter, the status quo of the industry and the product life cycle of EEE were addressed. This often caused the participants to elaborate on their role of influence and steered the conversation towards new topics. As a result, the conversation jumped between the prepared questions and participants' focus areas to keep the dialogue flowing. Moreover, thematic transitions occurred frequently and required additional follow-up questions on what the informants emphasised. Although the structure of the interview guide was not followed strictly, the guide facilitated a way to navigate between different topics and ultimately ensure that all topics were addressed. However, a few questions were more convenient to ask the retailer than the waste management companies and vice versa. Consequently, the responses carried different levels of details whereby some sub-topics were only covered briefly. Lastly, the interviews were complemented with a summary of the key aspects and comments addressed during the interviews.

4.2 Secondary Data

Before this thesis progresses to explain the methodology, this section highlights the acquiring of secondary data to complement the primary data and to give context and factual substance throughout the thesis. As the thesis is focusing on a well-established industry, a wide range of sources were accessible to illustrate characteristics of the EE industry, governmental policies, and previous research on reuse. The same applies to sources in support of a Circular Economy.

To provide a theoretical knowledge basis for the thesis, a literature review was conducted (Chapter 2). A literature review presents an overview of the available research on the specific topic of reuse. It can function as a stand-alone product, as a part of a research project write-up, or as a background section (Hempel, 2019). This thesis utilised the latter. In the literature search, a wide website search, therein Google Scholar, was primarily utilised. Moreover, there was a particular focus on international review articles and their sources as these largely summarise and cover previous research and cross-national findings. Previous Norwegian research on reuse is mainly centred around the construction industry and few relate to the EEE segment. Consequently, the inclusion of Norwegian literature was limited and rather focused on relevant reports and institutional statements.

The secondary data were utilised in the initial research phase (i.e., literature review and theoretical background) as well as in the support of the contextualising results from the interviews (i.e., barriers to reuse and implications). More specifically, relevant reports and statements were examined to address the status quo of waste management, reuse, and CE. This included an examination of the Norwegian government's Circular Economy Strategy, EU's Circular Economy Action Plan, IPCC reports, national and international legislation, as well as reports such as the Global E-waste monitor. Moreover, data from Miljødepartementet [the Norwegian Environment Agency], SINTEF, and Elektronikkbransjen [the Norwegian Consumer Electronics Trade Foundation] have been of significance when presenting relevant statistics.

5. Method

Different research methods and theories were applied to answer the research question. This section provides an overview of the thesis' research design and analytical framework, as well as a discussion on research quality.

5.1 Research Design and Methods

A research approach should reflect the most suitable way of addressing and answering the research question. Since this thesis aims to both identify barriers to reuse in Norway and discuss possible solutions to overcome these barriers, it was deemed appropriate to apply a qualitative methodological approach. This decision was grounded by the lack of publicly available and up-to-date data from both industry and institutions in Norway. Moreover, the thesis required a design that would allow the researchers to uncover a variety of industry procedures, trends, and perspectives. In summary, this justified the thesis' choice and adoption of methodology, namely qualitative methods.

Qualitative research allows a researcher to gain an understanding of a social phenomenon based on comprehensive data on people and their context, perspectives, and beliefs (Thagaard, 2003). Both interviews and surveys were initially considered upon deciding on a research approach for this thesis. Yet, interviews were evaluated with higher preference due to a greater opportunity for supplying detailed insights and a deeper understanding of context, barriers, and drivers to reuse. In comparison to quantitative methods, qualitative approaches "trade generalizability and comparability for internal validity and contextual understanding and are particularly useful in revealing the process that led to a specific outcome" (Maxwell, 2005, p. 81). According to Miles and Huberman (1994), qualitative research, therein interviews, make up a strong method for data collection which examines people's and companies' lived experiences and may reveal hidden assumptions. This is particularly relevant with the identification of barriers for reuse in Norway, whereby stakeholder perspectives are key to understanding the real contextual and influential factors. Nonetheless, the phenomenon of interest in this thesis relates to how one can overcome barriers to the reuse of EEE, whilst the process investigated corresponds to why reuse remains low in Norway. Since these topics have not previously been studied in detail, it demonstrates an exploratory design (Thagaard, 2003).

The research process is illustrated in *Figure 6* and further described in the following paragraphs.

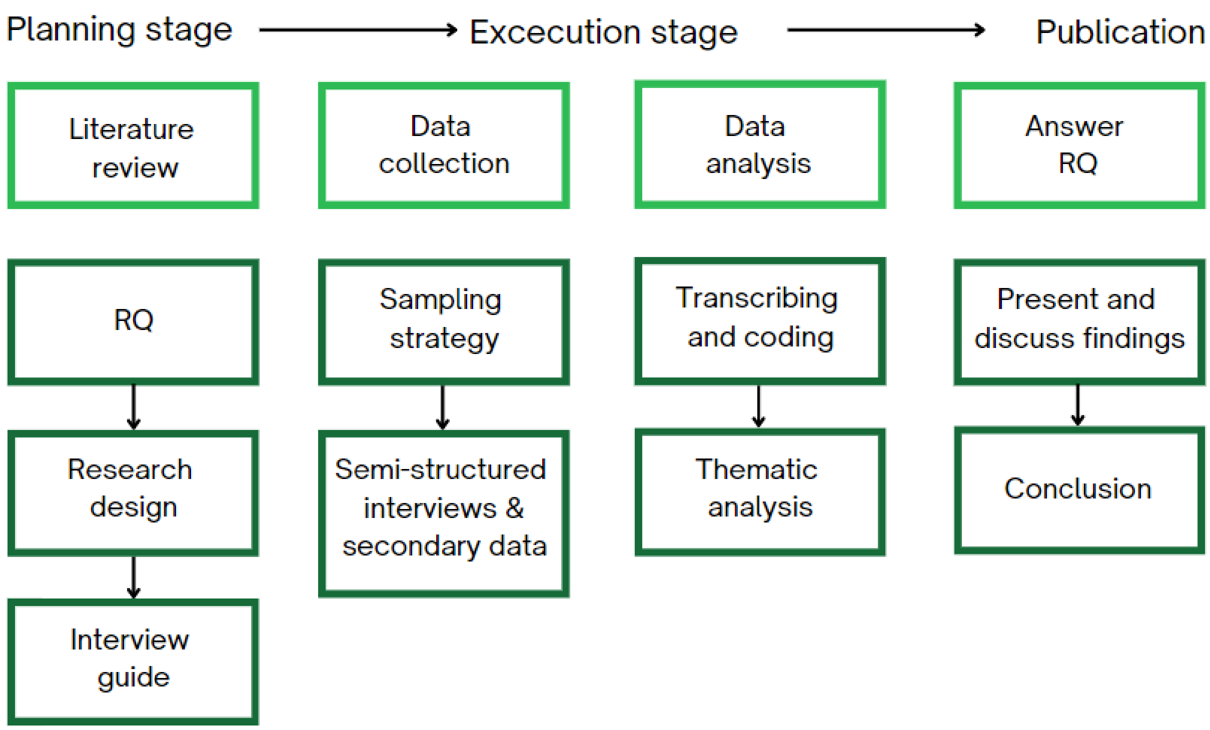

Figure 6: Steps of the research process

The research process was initiated with a literature search exploring previous research and theories. It showed that Norwegian E-waste management was widely covered by literature, but research on the reuse of EE products was understudied and underdeveloped. This engendered questions to discover why reuse remains low in Norway. Therefore, in parallel with examining available literature, an interview guide (i.e., questions) emerged. As mentioned in section 4.1, the interviews followed a semi-structured approach. This presents the advantage of allowing a researcher to follow the participant's narrative as it unfolds as well as opens the possibility of exploring topics that the researcher has not previously thought of (Thagaard, 2003). For this to be effective, it is important to keep track of the direction of the conversation and decide when or *when not* to interrupt a participant's response (Galletta, 2013). In such instances of decision-making, the interview guide was useful as it ensured comparability across interviews and safeguarded the researcher's control of the interview.

Overall, four semi-structured interviews were conducted to acquire insight into how the industry operated and which challenges they were facing. The interviews were held and transcribed in Norwegian, whilst quotations were translated when applied in-text. Transcripts were examined and categorised utilising a thematic analysis. The findings were later presented and discussed in Chapter 6. The discussion of barriers was structured by stakeholder groups as identified by the thematic analysis. Lastly, clusters were identified, and an initial examination of implications was provided. The exploratory design proved to be beneficial as it offered flexibility, thus making it possible to adjust the interviews and analyse the approach based on discoveries throughout the research process.

5.2 Data Analysis

This paper opted for a thematic analysis of the data obtained from the interviews. Thematic analysis is a widely used qualitative analytic approach for identifying, analysing and reporting patterns and themes within data (Braun & Clarke, 2006). The following six-step was employed to conduct the analysis:

Figure 7: Phases of thematic analysis
Retrieved from (Braun & Clarke, 2006)

As illustrated in *Figure 7*, the first phase focused on the familiarisation of data which included a detailed transcription of the audio recordings. Efforts were made to provide a verbatim account of the interviews although filler words were excluded. The transcripts were re-examined through which patterns that emerged were written down. The second phase began with assigning specific keywords to the data. These keywords (i.e., codes) largely summarised the essence of the participants' statements. By providing a rough overview of the data, it also introduced the next step, namely, the search for themes. The relationship between codes was mapped out, e.g., background on the industry, trends, waste management practices, national and international legislation, consumer behaviour, technical difficulties, and economic limitations.

Potential themes were thereafter reviewed to generate a thematic 'map' of the analysis. It was deemed advantageous to distinguish between three overarching themes due to the nature of the research questions: (i) the status quo, (ii) barriers to reuse, and (iii) implementation. Moreover, the first theme was divided into two data groups of insights, namely background on the EE industry and the status quo of reuse. The second theme relates to the thesis' focal point, thus requiring more prominence and emphasis in the discussion in Chapter 6. As barrier analysis is a complex and wide-reaching theme, it was necessary to structure the data into sub-themes from the identification of stakeholder groups. These were identified during the thematic analysis. In other words, the barriers were classified and linked to the stakeholder with the most responsibility for resolving them. Specifically, the stakeholder groups included are *Policymakers, Producers, Retailers*, *Workshops, Consumers*, and *Waste Management.*

5.3 Research Quality

It is crucial to ensure that the time, effort, and expense spent on data collecting are worthwhile. This is oftentimes evaluated regarding validity and reliability (Clippinger, 2017, p. 3). However, in qualitative research, these measures are applied differently (Shenton, 2004). It is thus necessary to utilise separate concepts. This section addresses the trustworthiness of the study as defined by Lincoln and Guba (1985), by assessing credibility, transferability, dependability, and confirmability.

Yet, before the specific categories are introduced, it is important to note that the trustworthiness of the study is also dependent on the trustworthiness of the participants. The researchers acknowledge that even though the data is anonymised, the informants may be influenced by their company's values or strategic priorities. Their position can also influence the integrity of their answers, e.g., the wish to not portray their stakeholder group in a certain way and thus withhold information. However, this is a continuous risk for qualitative research, particularly interviews, and thus this will not be addressed further.

5.3.1 Credibility

The credibility criteria, the equivalent of internal validity, refers to the truthfulness of the research findings. It establishes whether the participant's views and the researcher's representation of them provide accurate depictions of reality (Korstjens & Moser, 2017). There are several approaches to secure credibility in a study. One of which is triangulation, i.e., using different data sources, investigators, and methods of data collection (Korstjens & Moser, 2017, p. 121). The thesis´ findings are refined from a thematic analysis of interviews and accommodated by secondary sources which validate and provide context to the findings. By interviewing stakeholders in various parts of the value chain, different experiences and viewpoints were represented and could be verified by comparing the insights. Even though governmental authorities were not represented in the sample, which somewhat weakened the credibility, the findings constructed an aggregate understanding of the industry. It follows that when informants emphasised similar issues concerning reuse, the study's credibility was enhanced.

Moreover, credibility is also influenced by the methods in which data was collected and analysed. To ensure that the informants could engage in a detailed discussion about the EE industry, the researchers supplied a precise agenda allowing each interviewee to conceive of thoughts in advance of the interview. This is perceived to have facilitated a more comprehensive and insightful conversation. In addition, due to the flexible interview approach (i.e., semi-structured format), informants were subsequently asked follow-up questions to complement their initial elaborations. Lastly, a summary of key aspects at the end of each interview was performed as an informant validation. This ensured that the informants were interpreted correctly during the interview. Overall, the complementary follow-up questions and removal of ambiguities with informant validation were beneficial for research credibility. This was confirmed in the interpretation process of the data analysis. For instance, a measure to identify insights was pursued by each researcher individually wherein they assigned keywords and themes to the data. Initial results showed similar interpretations when compared, yet a few ambiguities arose. These were discussed and the ultimate definition of themes was done collaboratively.

The structure of the result and discussion of this paper (see Chapter 6) is another aspect that may affect credibility. There is no clear distinction between the two, potentially making it difficult to distinguish between informants´ views and the researcher's interpretation of them. However, quotations are used frequently, and the thesis supervisor was consulted to review the research process.

5.3.2 Transferability

Transferability relates to the extent to which the results can be applied to other settings with other participants. It addresses the applicability of a study, i.e., the degree to which a reader can transfer the findings to their setting. A study should include detailed descriptions of context, the participants, and the research process for a reader to make such transferability judgments (Korstjens & Moser, 2017). In Chapter 1, the context in which the research was carried out is described (i.e., unsustainable consumption and production of EEE). Furthermore, Chapter 4 describes the data collection process and Chapter 5 present an overview of the methodological approach. In combination, these sections should provide sufficient information for a reader to assess whether the results would be transferable to the situation, company, or industry they seek to explore.

The interviews provided insight into different features of the EE industry. Despite the sample only accounting for four stakeholders, they were scattered across the value chain and addressed industry-wide challenges. It is thus plausible that the thesis´ findings are applicable and can present generalisable findings to the whole industry. Moreover, companies in similar industries may benefit from understanding the different stakeholders' perspectives and crucial prerequisites for reuse. However, there are limitations to the transferability of this study. The degree to which it is transferable to other countries is weak as the thesis is limited to a Norwegian context. Nevertheless, as the thesis is written in English, it extends its findings to a broader audience and enables foreign researchers to observe and identify resemblances between Norwegian and non-Norwegian EE industries.

5.3.3 Dependability

The dependability criteria measure the consistency of the findings, i.e., the extent to which a study can be repeated in the same context, with the same methods, and produce a similar result (Shenton, 2004). This is the largest threat to the trustworthiness of this thesis as the Informants are anonymous, and the interviews followed a semi-structured approach. Hence, it will likely be difficult to reproduce the interviews. The flexible interview structure allowed the researchers to alternate and redirect between the predetermined questions. Furthermore, the later interviews placed a greater emphasis on topics that had not been adequately addressed in prior interviews. Consequently, it remains a process that might be difficult to precisely replicate. However, numerous enterprises in Norway's electronic sector are comparable to those included in this sample. These are almost certainly experiencing similar difficulties as described by the thesis' findings. By following the interview guide (attached in Appendix A) and targeting enterprises that operate in the same segment as those described in the data collection section, a similar result will likely be obtained.

5.3.4 Confirmability

The last aspect of trustworthiness is reflected by neutrality, which is addressed through confirmability. To secure confirmability in a study, interpretations, and findings should be derived from data, rather than reflecting the researcher's personal preferences and viewpoints (Korstjens & Moser, 2017). Like its application to promote credibility, triangulation can also promote confirmability by reducing the effect of investigator bias (Shenton, 2004). In the thesis, triangulation is present as several sources, methods, and investigators have been utilised. For instance, in the critical examination of theory (Chapter 3) where the presented concepts and topics were highlighted based on prevalence in the wider literature on reuse. Moreover, a similar examination was applied in the discussion (Chapter 6) whereby the topics addressed are grounded on data and its prevalence in the interview transcripts. Yet, it is essential to note that the thesis' findings are still founded in the researchers' understanding of raw data and literature, leading to an inherent investigator bias. Nonetheless, measures and conscious choices were included and discussed to limit the risk of bias. Another weakness for confirmability is the translations of quotations. Since the quotations were translated from Norwegian, it is plausible and should be highlighted that translation bias can occur. For instance, the content was deemed more essential than the wording. Consequently, the choice of words may have been lost in translation. Moreover, as both researchers have experience in the EE industry, the risk of biased opinion cannot be ruled out. Although this is a limitation, efforts were made to preserve the true content and reflection of the informants' perspectives and thus the researchers deem these risks as acceptable.

Overall, both confirmability and the other categories for trustworthiness have been acknowledged in advance of interviews and during the research process. It should be noted that during the research process, the researchers were neither employed nor actively involved in the EE sector and thus have no conflict of interest or advantages in presenting favourable research. The thesis aims to create objective and unbiased representations of the industry. This is imperative if other researchers and stakeholders want to utilise the findings of this thesis.

6. Results and Discussion

The following chapter presents and discusses the findings from the thematic analysis. The presentation of findings is divided into three sections to address the objective and research questions:

Objective: What is required for the Norwegian EE industry to overcome barriers to reuse?

RQ1: What is the status quo in terms of EEE reuse in Norway?

RQ2: What are the barriers to implementing reuse in the value chain of EEE?

The first section highlights insights into the current state of the EE industry. More specifically, it aims to contextualise both interconnections in the EE industry and how various stakeholders engage with reuse. The second section furthers the discussion on reuse by examining the present barriers to reuse in Norway. As emphasised in section 5.2, the analysis is divided into six stakeholder groups, namely *Policymakers, Producers, Retailers, Workshops, Consumers*, and *Waste Management*. The final section in this chapter, namely 6.3 – Implications, examines how the barrier identification influences potential suggestions and paths to increase the reuse of EEE in Norway.

It is considered necessary to highlight that the findings must be interpreted in the context of the sample. Firstly, the sample is inclined towards stakeholders that focus on reuse. The researchers argue that examining these stakeholders is the best-fitted approach to learning more about reuse potential in Norway. For instance, the informants offered different perceptions regarding their stakeholder's role in the EE industry. One may argue that *Informant 1*, who represents a retailer, and *Informant 2,* who facilitates the reuse of EEE, both have commercial interests in reuse. As a result, they provide knowledge on the economic aspect of CE. Concurrently, the entire sample has sufficient expertise to address the environmental aspect in depth.

Secondly, a consideration to highlight is the sample size. Sample size choices influence both the generalisability of the study and the potential depth of the analysis. Although the sample size could have been larger, the researchers believe that the expert opinions presented in this chapter adequately answer the research objective. Nevertheless, as there were inadequate data to conclude with statistical significance, the findings in this thesis represent indicative trends.

Note that henceforth, quotations or information might follow with (number) to indicate the informant source. For example, *Informant 2* equals (2).

6.1 Status quo in Norway

6.1.1 The EE industry

As a preliminary context, it is important to understand the size of the EE industry. In 2021, Norwegians spent approximately 43 billion NOK on EEE, an all-time high in terms of industry revenue (see Appendix B). Despite a year affected by the COVID-19 pandemic and regulations such as lockdowns, sales of white goods, gaming gadgets, and cooking utensils significantly increased (Ottemo, 2022). Notably, this was confirmed by three of the informants as they referred to the pandemic as a key driver for the sales growth (1)(2)(4). *Informant 1* highlighted the EE industry as 'winners of the pandemic' as the population is increasingly reliant on electronics for purposes such as smart homes, entertainment, and gaming. *Informant 3* went further in stating:

> During the pandemic, we bought an insane quantity because everyone worked from a home office. Our consumption has been extraordinary in comparison to a normal year, so it will be very interesting to see how much we are throwing away. (3)

To facilitate our increasing demand, several actors are involved in the different phases of the EEE life cycle. A distinct characteristic of EEE in a Norwegian context is found in the following quotation: "There is hardly anything [EEE] that is produced or designed in Norway […] so we import" (3). This is supported by literature wherein the majority of EEE is currently manufactured in Asia, making EEE a part of global value chains (Bachér, et al., 2020). Consequently, a single EE product may have been manufactured and assembled by up to 200 distinct subcontractors in multiple countries (Elektronikkbransjen, n.d.). *Informant 4* elucidated this by explaining that when the EE product eventually arrives in Norway, it has been imported by large retail chains such as Elkjøp and Power. Moreover, according to *Informant 3*, Elkjøp and Power control by far the largest market shares in the Norwegian B2C market.

The precise number of companies that supply products and services in the EE industry is challenging to determine. Nevertheless, many of them are organised through Elektronikkbransjen. This foundation consists of around 1000 member companies ranging from importers, manufacturers, distributors, chains, retailers, and workshops (Elektronikkbransjen, 2022b). About the foundation, *Informant 2* stated:

> The EE industry in Norway is almost 100 years old. The difference between us [Norway] and other countries is that we organised all the different trade associations into Elektronikkbransjen in the late 1990s. We are the only one in Europe that has the entire value chain in one organization. As a result, when we want to adapt to directives, we sit around the same table and can make effective decisions. (2)

For instance, the WEEE Directive is considered one of the most prominent directives for companies selling EEE in the EU. Norway is bound by the Directive as an EEA member (Miljødirektoratet, 2021b). Accordingly, it is implemented in national regulation through Avfallsforskriften Chapter 1, which regulates the reception, collection, recycling, and other treatment of EEE waste (Avfallsforskriften, 2004, § 1-1). For instance, municipalities and retailers must ensure that the possibility of reusing WEEE is not debilitated (Avfallsforskriften, 2004, §§ 1-5 and 1-8). Accordingly, the Norwegian WEEE regulation entails legal responsibilities for retailers, municipalities, producers, and WEEE compliance schemes.

During the interviews, this was reflected as important by the frequent mentioning of the term *Extended Producer Responsibility* (ERP) to allude to the legal obligations. *Informant 4* explained that the concept indicates that the entity that introduces a product on the market is also responsible at the end of the product's life cycle. Moreover, *Informant 3* emphasised that "it is not a matter of producers in its original form, but the brands such as Miele, Samsung or Apple. We do not have these in Norway – therefore it is the importers who are responsible" (3).

In Norway, *Informant 3* further elucidated that EEE can be disposed of in one of two ways: at a municipal recycling station or a retailer selling the same type of products. Concerning retailers, *Informant 4* specified that "it makes no difference whether it [EEE] was purchased there or not" (4). Consumers can dispose of EEE free of charge due to the EPR. This is because producers and importers are required to fund the collection, sorting, and treatment of EEE waste by joining an authorised WEEE compliance scheme (Avfallsforskriften, 2004, § 1-10). The WEEE compliance schemes ensure that producers meet their obligations. According to *Informant 2,* there are four of these in Norway, and *Informant 3* who represents one of them explained:

> We have contracts with collectors and treatment plants and manage and control the entire flow of waste […] until the refrigerator has become new plastic or metal in other products. All monitoring, reporting and figures go through us. We have an overview of everything that is imported, discarded, exported, as well as downstream until the gold in the circuit board has turned into a new gold bar. (3)

According to the statement, mechanisms are in place to monitor and manage material flows. Both *Informant 2* and *3* highlighted that the Norwegian market has an extraordinarily high rate of material recycling, and thus it is difficult to find areas for improvement. *Informant 3* followed up the claim by stating: "What we can get better at is increasing reuse" (3).

6.1.2 EEE Reuse

The importance of reuse is manifested by its rank in the waste hierarchy. As mentioned previously, Norway produces an enormous quantity of E-waste. The sale of reused products may partially mitigate the environmental impact of increasing waste streams, and thus reuse has arguably surfaced on the agenda because of the international and national focus on sustainability and a circular economy. Yet, Norwegians have not previously consumed reused goods. This is supported by *Informant 3* who argued that there has not been any notable second-hand market presence.

However, there appears to have been a shift in the market. *Informant 1* stated that "reuse and second-hand trading are becoming more normalised. This applies in the clothing industry, EE industry, and the public sector" (1). Still, not all consumers buy second-hand goods. The findings suggest that the reuse of EEE is led by the youngest generation. The elderly, on the other hand, do not purchase second-hand products according to *Informant 3*. In support of the claim, it is argued that "some consumers do not know what reuse is – It is not part of their vocabulary" (4). In other words, the informants appear to support the notion that for wider adoption of reuse there is a need for change in consumer attitude and realisation of the environmental benefits.

This change seems to have emerged amongst certain Norwegian consumers, both in understanding the reuse potential and awareness of companies' sustainability standards. A prevalent company in the Norwegian industry in 2021 was *Finn.no*. They received the highest ranking amongst Norwegian companies in the Sustainable Brand Index which examined consumers' perceptions of companies' sustainability efforts (SB Insight, 2022). Note that *Finn.no* is the largest online marketplace in Norway (Robert Fijalkowski, 2020). Their prevalence was highlighted in this thesis findings, where *Informant 1* recalled that *Finn.no* has approximately 1 million advertisements per year in the home appliances and electronics category. Furthermore, the informant noted that the retail company represented sells reused EEE through Finn.no and their company website (1).

There appears to be a consensus amongst the informants that the EE industry is attempting to become more environmentally friendly. According to *Informant 3*, Clas Ohlson reflects some of the trends by their recent introduction of a sharing platform for tool rental. It is also highlighted that several retailers in the market are requesting repairable products as well as products made from recycled products in their stock (1). The consensus amongst the informants is also supported by findings from other studies, such as an increasing collection, repair and upgrade of discarded EEE by companies for the purpose of resale (Nørstebø, et al., 2020). Hence, the data suggests that the industry is on a path of change, with several stakeholders implementing reuse in their business models.

Another example which can be derived from the interviews is how the largest retail chains have introduced trade-in services, namely the process of a consumer delivering a EE product in exchange for a discounted price on their next purchase (1)(2)(3). *Informant 2* explained that the scheme's basic principle is to resell products that still have market value. This implies that the retailers attempt to adhere to the waste hierarchy by reselling usable products instead of deeming them as waste. *Informant 1* who represents a retailer clarified the process by emphasising that it is the contractual partners that determine where the products end up. This is based on an assessment of where the products have the highest value (1). These products are not necessarily deemed acceptable for resale in Norway. This is mostly due to the scale and influence of second-hand markets in other countries (1)(3).

Nevertheless, initiatives promoting reuse are continuing to emerge in Norway. The organisation represented by *Informant 2* is a pertinent example of a stakeholder pursuing such endeavours. The informant explained that they have created an approval scheme for reusing consumer electronics (2). It includes a two-year exchange guarantee for reused EEE, workshop and retailer certifications, a joint logo, and a database for the entire Nordic region (2). The scheme aims to improve both the supplier's and customers' success and security in exchanging used products. More specifically, "the product's brand, model, serial number, date of sale and compliance scheme company are registered in a database – This allows you to see who has repaired the product and who is accountable for the warranty" (2). At the point in time of the interviews, the scheme had 60 contractual partners including suppliers (e.g., Miele, Samsung, Electrolux, Siemens, Whirlpool and Grundig), the major retail chains, compliance schemes, and some workshop chains. Regarding the retailers' involvement, *Informant 2* noted:

> Power plans to have this [reused EEE] in most of its 120 stores, but they have only started with two – and they are first. Elkjøp [...] has not gotten as far as Power yet but sells reused products via outlet. (2)

The initiative underlines the argument that the EE industry is willing to implement reuse in its business models. Furthermore, the project's legitimacy is enhanced by the involvement of several well-known stakeholders. However, as signalled by *Informant 2*, reuse in the B2C market remains limited in scope.

Private individuals do not necessarily make up the largest share of the second-hand market. This is exemplified by insights such as "when Equinor buys mobile phones for all its employees; they buy 3,000 mobile phones. The existing phones are collected by the employer, and we get a large B2B market" (3). As a result of employing the B2B market as a collection point, one may obtain EEE in large quantities and have increased authority over how products are treated once they leave the former owner's possession.

Although several entities are involved in reuse, *Informant 4* indicated that no current figures are covering the whole size of the second-hand market. Nevertheless, WEEE Compliance Schemes have reported that 2% of WEEE was prepared for reuse in 2021 (see Appendix C). Note that this figure accounts for products that have already been disposed of, thus purchased EEE higher up in the value chain was excluded from the data. Even though it may appear little in percentage terms, it is a significant number in tonnes. Furthermore, an interesting remark was made by *Informant 3* which stated that the figures are not entirely representative as the pandemic has increased both the consumption and disposal of goods. Moreover, it is further specified that the WEEE Directive is currently being revised and that once completed, it will provide a new method of counting that will improve the data on reuse (4).

The findings in this section suggest that there undoubtfully exists a market for EEE reuse in Norway. However, it remains limited and thus various barriers must be addressed to accelerate the reuse of Norwegian consumer electronics. These are presented in the following section.

6.2 Barriers to reuse

This section addresses the thesis' main findings, namely identifying different barriers to the reuse of EEE in Norway. The barriers are categorised and discussed by stakeholder perspectives, representing the groups: *Policymakers, Producers, Retailers, Workshops, Consumers*, and *Waste Management*. At the end of the section, a summary of the identified barriers is presented.

6.2.1 Policymakers

The EU plays an imperative role in facilitating the transitions toward a CE, as the industry alone does not necessarily have sufficient incentives to induce an endogenous change. For instance, the EU defines strategies, directives, and regulations affecting the EE industry (e.g., the WEEE Directive, the Eco-design Directive and the CEAP) whereas national authorities must adopt these into the national law (European Union, 2012). This is considered key in facilitating a circular transition. Therein, *Informant 1* highlighted the importance of the EU concerning reuse:

> While many people in commerce [industries] are very concerned about consumer power and that the consumer has become more concerned with sustainability, I do not think that it is going to be the main driver of reuse in our industry, it is going to be the price of raw materials and demands from the EU. (1)

There is an agreement amongst the informants that the EU should act as an accelerator for reuse. However, the findings suggest that there is a lack of clarity in EU regulations. *Informant 1* elucidated that the EU does not force reuse into business models, but rather expresses that "they want, they would like to see, they want to stimulate, or they support innovation funds" (1). This suggests that the EU is trying to facilitate reuse but without sufficient and *specific* requirements.

The required rate of recycling and reuse exemplifies an instance where the regulations are open for interpretation. For example, the phrasing of minimum targets in the WEEE Directive reads: "55% shall be prepared for re-use and recycled" (Directive 2012/19/EU). This phrase also appears in the Norwegian requirements (Appendix C). *Informant 2* emphasised that it does not explicitly state that Norway *must* prepare a given amount of WEEE to reuse. Thus, the problem is that one is free to choose between recycling and reuse which can lead to one being prioritized over the other. Due to costs and operational considerations, it is possible that recycling may be prioritised over reuse as it is considered a less demanding process.

Another example of unclear phrasing occurs in the CEAP concerning the right-to-repair, in which one should be able to repair EEE (European Commission, 2020a). Before discussing it any further, note that the CEAP is a strategy and not a legal regulation. According to *Informant 2*, the action plan does not state who can or cannot repair EE-products. Therein, it is difficult to assess if it is the user, a technician, or the producer. Furthermore, *Informant 2* stressed that there are strict rules to who is allowed to repair products and what components can be used, i.e., authorised repair shops and original spare parts. Thus, by letting consumers repair their products, warranties provided by producers may be violated (Hernandez, Miranda, & Goñi, 2020).

Another consideration with relevance to consumer rights was brought up by Informant 2 who argued that a warranty on reused EEE is necessary to provide extra security for consumers. As of today, consumers have a statutory right to complain for two years (Directive 1999/44/EC). In Norway, the appeal period is extended to five years for products that are meant to last *essentially longer* than two years (Forbrukerkjøpsloven, 2002, § 27). However, these legislations are not specific to reused goods. Simultaneously, many consumers are not aware of these rights. In a survey from 2019, only one out of ten in the age range 18-29 were aware that mobile phones had a five-year appeal period (Forbrukerrådet, 2019). Moreover, it may be difficult to distinguish between products that are meant to last for two years and those which are meant to last *essentially longer*. Consequently, due to the lack of clearness, consumers may discard products that could have been repaired and covered by the Act relating to consumer purchases, namely Forbrukerkjøpsloven.

While the abovementioned barriers to a large extent have concerned inter-governmental policymakers, it is just as important to discuss barriers imposed by national policymakers. Despite the Norwegian government's effort in promoting the National Strategy for Circular Economy (Regjeringen, 2021), the findings suggest that the government should take a more active role in the circular economy policy. Furthermore, the whole sample emphasised the importance of public regulations as a driver to increase reuse.

The most frequently mentioned barrier is Value-added-tax (VAT), a governmental fee on domestic consumption of goods and services, ranging from 12 to 25 per cent (Innst. 3 S, (2021-2022)). There was an agreement between three informants that VAT on second-hand products, repairs and spare parts has a vast impact on consumers' approach to reuse (1) (2) (3). *Informant 1* stressed that it is one of the foremost barriers faced by the Norwegian EE industry and that a VAT exemption can contribute to the increase in reuse. Several stakeholders in the EE industry concede with the informants' view on VAT. In 2022, eight Norwegian companies and environmental organisations collaborated and delivered a letter to the Ministry of Finance highlighting the issue of high repair costs in many EE products (Måge, et al., 2022). *Informant 2* explained that:

> We compete with used products sold on *Finn.no* without VAT. It would be fair to remove the VAT as it has already been paid once on used products. A 25% deduction on a product through VAT exemption will have a large effect on the number of units you can sell reused. (2)

Informant 3 claimed that the Ministry of Finance has not yet approved the suggested reform and criticised the fact that VAT exemptions are not part of the government's circular economy policy. Moreover, both *Informant 2* and *Informant 3* specified that the government is slow to enact regulations. Criticism was also vocalised by *Informant 1* who claimed that several regulations should have been implemented years ago.

Another consideration worth mentioning relates to the ownership of waste. *Informant 3* elucidated that the ownership of WEEE is a bit complicated as retailers and municipalities (the waste reception centres) can sell discarded EEE to whomever they want. This seems to differ from the idea of products being recovered by compliance schemes wherein the schemes must adhere to strict data collection and ensure sound treatment of WEEE. The informant approved of the idea that it does not necessarily have to be a company with EPR that collects the goods. Yet, it was emphasised that the authorities to some extent have paved the way for illegal E-waste. Therein, *Informant 3* highlighted the problem that minor companies are exporting WEEE to Africa where there are insufficient procedures in place to prepare products for reuse (e.g., testing and warranties) and properly process WEEE. The latter was illustrated with a specific example, namely that refrigeration products are crushed in a large "car crusher", releasing GHGs contributing to ozone depletion. Hence, there is a clear need for specific requirements on how to regulate and assign ownership of waste, mainly to improve the reuse of waste.

Yet, it is also argued that the preparation process for EEE reuse may not be best situated with the municipalities. This is mainly due to the uncertainties regarding who should be responsible for the products when EEE is reused. The matter was addressed by *Informant 4* in the following statement:

> If you pick out a microwave oven and sell it, and later it starts to burn when the new customer has it in his home. What does the law say? Who are responsible? Used EEE needs to be […] tested, verified, and approved by a third party. It's not just to pick out something that looks nice and use it again. (4)

Hence, it appears to be vital to safeguard the quality of reused products through verified testing procedures and guarantee policies. Policymakers seem to play an essential role in this process; however, the thesis argues that producers must bear some of this responsibility.

6.2.2 Producers

It is ultimately the producers who are responsible for making products more fitted for reuse. As highlighted in Chapter 3, current products are mainly linear in design and thus not feasible for reuse. *Informant 4* stressed that “there is a lot today that cannot be repaired. The producers do not allow it in design, so it must be discarded”. In other words, the cradle-to-cradle principles are not present, leading to a need for an imperative change in the way producers think about product design. This seems to be a critical requirement if Norway is to increase its reuse rate.

While repairability is considered key in making EEE more feasible for reuse, it also features an obstacle, namely that EEE does not withstand moisture. This was exemplified by *Informant 1* concerning mobile phones:

> It must be welded so that no moisture gets inside, and it is secured. As a result, batteries cannot be replaced. Our use of the phone today means that it may not be as repairable on anything but software, because once you have something that can be opened, you also have a place where moisture can enter. (1)

The concept of repairability may thus be difficult to implement for certain product categories. About the note on software, Informant 4 agreed. The informant indicated that the lifetime of products today could be extended, given better software (4). As with making EEE more repairable, improvement of software would require investments in new technologies and a change in product design.

Additionally, not all products are feasible for reuse. This might be for a variety of reasons, including environmental, safety, sanitary, and economic considerations. According to informant 1, “hair dryers and other hygiene items have little residual value”. This is further supported by the insight that personal care appliances are typically found in the lowest-cost product category, making reuse unprofitable (2). In addition, products that are prone to prolonged use may not be worth repairing (2). Hence, some products must be disposed of due to wear and tear or safety requirements.

Even though the abovementioned barriers are present, there are examples of producers who are improving and incorporating repairability in their product designs. One of which is *Fairphone,* a producer of modular mobile phones that allows users to disassemble and repair the phones themselves (1). On top of that, *Informant 1* mentioned that Samsung and Apple recently announced that users will be able to repair their phones themselves. The latter suggests that the market is changing as the two identified companies are arguably market drivers in EE technology. Whether producers are attempting to facilitate a circular transition deliberately or because of the introduction of the EU initiatives such as the right-to-repair, is unclear. Therein, a parallel can be drawn to the EU Commission's request for producers to present a solution for universal chargers. According to

Informant 1: “Nothing has been done about it, so the EU must regulate. In general, it is very hard to stop doing things you make money from” (1). The last remark is transferable for both producers and retailers. The implementation of reuse and repairability would likely reduce sales volumes, thus leading to a reduction in revenue. Hence, it imposes a conflict between the prioritising of sustainability and profit.

Another highlighted consideration is the significance of having spare parts available so that repairs may be conducted. For instance, if the motherboard of a washing machine breaks, there must be available spare parts and skills to replace it. Otherwise, the potential for reuse will be reduced. The barrier was highlighted by *Informant 2* who indicated that suppliers have struggled to supply enough spare parts for many years, resulting in downsizing workshops and causing products to be replaced rather than repaired. Moreover, it was asserted that EEE manufacturing should be more streamlined, as it is impractical to have spare parts for every product (2). The availability of spare parts is thus crucial both for the commercial resale of EEE and for individuals' efforts in extending a product's lifespan. Yet, the repair opportunities or information regarding repair are often distributed by retailers and handled by workshops.

6.2.3 Retailers

First and foremost, the findings suggest that reused EEE are presently not widely available in retail stores. Furthermore, there seems to be a lack of CBMs in the EE industry. Closed-loop initiatives in which customers may participate in value recovery are scarce. There are efforts in promoting reuse, but the diversity and adoption of products are still in the early stages. It was emphasised by *Informant 1* that there is a lot to learn from the car industry: “When you enter a car store, you are asked right away whether you want to buy or lease a new or used car” (1). In the EE industry, this approach is atypical as it challenges the current profit-driven business models.

Regarding EEE value chains, *Informant 4* explained that retailers have a margin per product and thus need to maximise sales to increase earnings. Consequently, the retailers lack interest and might even be disincentivised in pursuing options for reuse. Furthermore, the EE industry has long been criticised for focusing excessively on sales volumes, pushing consumers to buy more and better devices (3). This may affect the public's perception of retailers' commitment to sustainability. The latter is amplified by the fact that consumers have low confidence in environmental information provided by commercial entities (Forbrukerrådet, 2021).

Regardless of criticism, retailers are attempting to facilitate reuse but it imposes economic obstacles. The process of preparing products for sale is different for reused EEE compared to new products. *Informant 1* explained that:

> For new products, this happens automatically with the on-boarding of product information and information from suppliers. However, on reused goods, you need to take a picture of the specific product, and it requires manual handling. (1)

For instance, if a damaged refrigerator is to be resold, the retailer must document the product's condition in writing and with photos. This imposes additional handling costs and requires a certain degree of competence.

For retailers to fully include reused EEE in their product portfolio, the employees must be properly trained. *Informant 1* compared the handling of reused EEE with *Fretex*'s clothing sorting plant. In both instances, competence is required to distinguish between what has value and what has not, the degree to which products are suitable for reuse, and ultimately how the products should be handled (1). Due to the wide range of EEE, these considerations may differ significantly between product categories.

The findings also suggest a lack of monitoring at retailers' and municipalities' waste reception centres. *Informant 3* explained that there is little oversight of the process by which customers dispose of EEE. As the interaction with the consumer is minimal, it is difficult to trace product service history and determine whether the products are suitable for reuse or not (3). Furthermore, the retailers are unable to assure that users are disposing of EEE carefully, which would help to retain the product's value and enhance the likelihood of it being reused.

6.2.4 Workshops

The workshops, or repair shops, play an integral role in preparing products for reuse. In its simplest form, these workshops are responsible for making products ready to enter the market again. However, the preparation of EEE for reuse faces technical challenges. Therein, one challenge is that EEE encompasses a wide range of goods and components which exist in a variety of shapes and sizes and are not universal. As a result, facilitating a new life for such goods is a complex and resource-intensive process.

Moreover, the main barrier addressed by the informants is the costs associated with preparing products for reuse. Labour, material, and administrative expenses are all considered when determining the resale price of EEE. Preferably, these expenditures should be minimised to profit from reuse. This is not always the case in a Norwegian economy characterised by high wages and taxation levels. Due to low-profit margins and the fact that companies cannot charge much for reused EEE, *Informant 1* argues that one cannot spend too much time on repair and expensive spare parts as this massively increases the costs. The same applies to preparing a product for resale. *Informant 2* advocates that EEE should be tested by authorised personnel before resale. Furthermore, the importance of cleaning is also highlighted:

> Would you buy a used refrigerator if this had not been completely washed clean? We cannot do this mechanically, so we need people to do the job. This is perhaps the most important job we do in the process of reusing large appliances - because you cannot sell a washing machine, dishwasher, fridge, or freezer unless it smells almost new. (3)

In other words, preparing products for reuse entails great salary expenditures which diminishes the profit margin. Therein, it raises the question of who will bear the cost of reuse preparation.

Lastly, the availability of workshops and entities specialising in reuse is imposed as another barrier. Reuse should happen locally as transporting goods throughout Norway is both expensive and unsustainable (3)(4). Yet, the findings suggest these entities are spread across Norway but do not make up much in numbers. Accordingly, there is a need for more employees. More specifically, the predominance of these should come from vocational education (Nørstebø, et al., 2020).

6.2.5 Consumers

Norway has long been internationally renowned for high standards of living, therein large portions of the population experience economic freedom and high disposable income (Organisation for Economic Co-operation and Development [OECD], 2022). Thus, it is plausible to presume that many have the financial means to purchase goods. Note that this is not generalisable to all Norwegian citizens and the researchers recognise that economic inequality has risen in Norway (Aaberge, Mogstad, Vestad, & Vestre, 2021). Yet, due to the scope of this thesis, this will not be addressed further.

The economic freedom and high standards of living have a significant impact on Norwegian consumption and commercial activity. Recall that Norwegians spent more than 43 million NOK on EEE in 2021. According to *Informant 3*, the Norwegian threshold for discarding products and replacing them with new ones is low. Moreover, it was emphasised that consumers tend to acquire the latest (newest) products (3), which fabricates a culture of continuous materialism in Norway. Hence, it can be argued that this culture restricts consumers' environmental considerations (i.e., as they keep replacing their products). This is mainly fueled by the major brands (e.g., Apple) which release new products every year to maintain their sales volumes (4).

Moreover, these findings also support the notion that consumers prefer new products in comparison to used products. Even though consumers are more environmentally conscious today than they were ten years ago (4), it is not the case that all consumers seek out sustainable options when purchasing new products (3). Scholars confirm that second-hand products such as electronics and kitchen appliances oftentimes are stigmatised as being for people with a lower socioeconomic status (Wit, Haigh, Daniels, & Christiansen, 2020). This coincides with *Informant 1's* perception that it is challenging to make reused EEE attractive for customers. This might be due to mistrust of second-hand goods.

It is not simply mistrust which affects consumers' willingness to purchase reused goods, but also the price level. As argued in section 6.2.4, with the high processing cost of preparation for reuse, the resale price tends to be inflated. As consumers are considered price-sensitive (Oslo Economics, 2021), the resale price must be lower than the equivalent price of a new product. This was highlighted by *informant 1* who claims that the average consumer is not willing to repair a product if the cost is exceeding 30 – 50% of the price of a new product.

Yet, the price is not the sole barrier to reuse in Norway. How consumers handle their equipment can also be an obstacle to the reuse of EEE. This applies in two settings: (i) when products are in use and (ii) when they are discarded. For EEE to be feasible for reuse, consumers must care for the products differently than when they are to be recycled. One of the informants drew on an example from daily life to illustrate the first setting:

> Previously, we handled our laptops very carefully. Today, I take my laptop out to the garden, bring it to the cabin, and toss it all over the place. My children throw it into bags along with everything else – then it [EEE] must endure it too. (3)

In the case where EEE does not withstand the usage, the products should be subjected to repair rather than being replaced. According to *Informant 2*, inducing consumers to repair EEE themselves is 'farfetched' and does not work in practice (2). This perspective is reinforced by *Informant 1*, who recalls that you need a PhD or engineering degree to be able to repair your phone. Additionally, determining the residual value of a product and whether it is best suited for repair, reuse, remanufacturing, or recycling might be difficult for the average consumer.

Lastly, the emphasis on sound treatment when products are to be disposed of was exemplified by *Informant 2*: "If you are going to use a TV again, the screen must be intact, because it will have a large impact [value loss] if the screen is broken and needs to be repaired" (2). This is not only applied to televisions but is arguable relevant for just about every product (for instance, ceramic stoves, mobile phones, washing machines and computers). This thesis argues that the aforementioned statements on sound treatment and understanding conditions for reuse/repair may be transferable to consumers in general. Thus, the findings suggest that it is essential that consumers must learn to be more careful in handling their possessions to retain the possibility for reuse.

6.2.6 Waste management

It is not only the consumers who need to be more careful in handling the used EEE. The findings also showed that waste management plays a significant role. Several barriers faced by waste management companies have already been addressed in previous sections. These include the lack of oversight at the waste reception centres, the need for competence to evaluate reuse potential, and the dispute over who owns the waste. Concerning the latter, *Informant 4* explains that "the more control you get over the [WEEE] flow, the more you can reuse" (4).

In addition, the collector's handling of EEE may reduce the potential for reuse. *Informant 3* explained that "when we collect E-waste, we do not receive it with our hands and put it nicely in place. There are trucks, giant machines, and excavators that lift and throw things away" (3). These machines may inflict a loss of value on products. Thus, resource recovery gets prioritised over product life extension. Accordingly, consumers, retailers and municipalities must recognise the potential of E-waste as an important resource to reuse.

6.2.7 Summary of Barriers

Before implications are discussed, it is deemed necessary to summarise the barriers which have been identified. It should be noted that implementing reuse in Norway requires collaboration across the value chain and is thus a complex process with multiple dependencies. Accordingly, several barriers are interlinked, either directly or indirectly. Thus, there are some recurring themes. This is indicatively presented in *Table 2* below.

Table 2: Barriers to reuse

Policymakers	**Producers**	**Retailers**	**Workshops**	**Consumers**	**Waste management**
Unclear regulations	Sustainability < Profit	Sustainability < Profit	Economically unsustainable	High consumption	Mechanical processing
Lack of minimum requirements	Low-quality EEE	Consumer scepticism	Requires more employees	Prefer 'the latest news'	Requires competence
Recycle > Reuse	Not all EEE are feasible for repair	Requires competence	Availability of workshops and spare parts	Not able to repair themselves	Reception not monitored
VAT	Linear design	Reception not monitored		Price sensitive	Ownership of waste
Ownership of waste	Availability of spare parts	Lack of CBMs		Irresponsible treatment	

6.3 Implications

The previous section highlighted foreseen and perceived barriers to increasing the reuse rate of EEE in Norway. Yet, there are arguably some barriers which stand out, i.e., have increased saliency, based on informants' focus during interviews. These include the findings on the linear design of products, economic unsustainability, consumer scepticism, lack of clear regulations and product value loss due to irresponsible treatment. This section addresses these specific barriers and presents recommendations as to how one can overcome them to enhance reuse in Norway.

A common denominator is that it is essential to perform improvements before production. Producers must forgo the linear designs and direct their attention to repairability and durability. Fairphone's modular design attempts this whereby consumers can maintain and repair their own devices. This *redesign* of the production process is a recurring feature in CE (Kirchherr, et al., 2017), and thus a salient intervention for increasing reuse rates in Norway. Only by making this the new norm is CE truly fulfilled, as highlighted in Chapter 3. Moreover, this entails that the producers introduce user manuals available to the public with clear instructions on how to disassemble and repair the products. Spare parts must also be available for several years after products are retired from the market, and one could establish a criterion for the maximum number of steps in disassembly.

It follows that incorporating designs such as modularity results in changes along the entire value chain of EEE production. For instance, suppliers must offer durable hardware and high-quality materials, and producers must find new ways of assembling their products (e.g., using screws rather than glue and welding). This cannot apply to all product categories due to technical limitations. Therein, it presents a trade-off between repairability and durability where improving one feature will aggravate the other. Yet, it would allow for product life extension and the repair of certain goods that are currently difficult to dissemble. In the long run, the low-quality product segments which are not feasible for repair should be renounced. By only producing high-quality EEE, the products would last longer, the need for repair would be significantly reduced, spare parts would be more available, and a higher fraction of EEE would be feasible for reuse.

Extending the lifespan of EEE would necessitate suppliers, producers, and retailers to adapt to new business models. This is because more durable products and an increase in EEE resale are likely to cause a reduction in total sales volume. Thus, the entities must identify alternative ways of generating revenue. This might involve implementing CBMs. On the one hand, producers and suppliers could to a larger extent use fully recyclable, high-quality materials as input in the production process (i.e., *circular supplies*). Hence, mineral extraction costs should be reduced as components and materials are returned to the producers after use. On the other hand, retailers could introduce *sharing platforms* by lease and rental, and *product as a service* by offering subscription services in collaboration with workshops. The latter could involve maintenance and repair services inspiring long-term relationships with customers. To incentivise companies to embrace CBMs, one suggestion is to ensure that those who contribute to the shift towards CE profit financially, while those who do not could e.g., face higher taxes. The preferable effect is that more companies would shift towards CE by finding clear competitive advantages. If market competition increases, the price of reused goods and repairs is likely to decrease. However, this requires the involvement of governmental policymakers.

A specific measure that may ease the financial burden of reusing EEE involves the reduction or complete removal of VAT. This is supported by the *Informants* and a survey of 1003 Norwegians, whereby 86% agreed that VAT should be reduced or removed in repair services (Forbrukerrådet, 2021). The measure should preferably apply for repair, spare parts, and the sales of reused EEE. The thesis presumes that customers are price sensitive and will thus respond positively to a price reduction on repair and second-hand goods. Although this may sound straightforward, it might not necessarily be the case. An expert committee appointed by the Ministry of Finance concluded that VAT should not be used to address environmental concerns as the effect is uncertain and it involves increased administrative costs to delimit what is covered by a potential exemption (NOU 2019: 11).

The concerns raised by the Ministry of Finance should not be taken as given, but rather more examinations on the effect of VAT should be conducted. For instance, it is important to understand the effect of removing VAT might differ across product categories. According to Oslo Economics (2021), projections show that the highest effect would be on white goods due to the feasibility of repair and market presence for repairs. Moreover, repairs can take place at customers' homes, and repairers are willing to transfer VAT reductions to the customer, i.e., lowering the price to remain competitive (Oslo Economics, 2021). Furthermore, the effect on computers and mobile phones is considered moderate, as devices become obsolete relatively quickly (i.e., short life span) and customers may still opt to purchase new products (Oslo Economics, 2021). This is also likely to be influenced by the culture of having the latest product offerings. Even though the potential effect on mobile phones and computers was considered moderate, it is still projected to increase in the future. This projection is judged due to the EU's promises in the CEAP of implementing regulatory measures to promote durability, reparability, and upgradability in product offerings (European Commission, 2020a).

A limitation surrounding the demand for VAT reductions in the EE industry relates to potential domino effects. This might arise if other industries (e.g., clothing, furniture, food services) also demand VAT deductions. If this occurs, it is probable that the government estimates a higher risk for significant income losses and thus opposes such incentivisation. Yet, this thesis argues that the national authorities should rethink their stance or possibly launch a subsidy scheme. The industry requires assistance in promoting the competitiveness of reusable goods in the market. The preferred approach should be similar to how electric car policies have made it beneficial to opt-out fossil-fuel-powered vehicles.

Another instance where the Norwegian policymakers may intervene to enchase reuse is by establishing specific requirements for reuse in the national waste regulations. This should provide a better regulatory distinction between reuse and recycling, preventing recycling from taking precedence over reuse. On the other hand, it might be difficult to estimate numerical reuse standards since there will always be products that are not deemed suitable for reuse. It might also be counterproductive to use a different counting system than the one established by the EU. Hence, the EU may be more responsible for enacting legislation to enhance reuse rates. Yet, this thesis argues that the Norwegian legislators are more fit and effective in understanding the local needs for the Norwegian waste landscape and thus further research on how such distinctions can be made is necessary.

Moreover, considering that Norway has minimal influence on international producers and suppliers, the government's focus should be on retailers, consumers, and local waste management. A critical point is to collect products before they are treated as waste and lose value. This could require manual monitoring at waste reception centres. For instance, customers could be greeted by an operator who makes a quick inspection of the goods and asks questions to assess whether the products are fit for reuse. Important insights to uncover may include the reason for disposal, date of purchase, and whether it is functional or broken. The operator may then be able to categorise EEE as functioning, repairable, or disposable. However, as highlighted in section 6.2, it is costly with manual processes especially when envisaging that a qualified operator would need to be present at every reception point across Norway. A cheaper alternative is thus to designate areas at current reception centres to these categories (i.e., functioning, repairable, or disposable). Therein, the responsibility is to a greater extent transferred to the consumer. Both proposals would reduce the risk of value loss caused by consumers and waste management companies. To mitigate the risk further, it would require sufficient infrastructure (to prevent moisture from entering the products), funding and national regulations to be realised.

Another suggestion that would preserve the value of EEE involves expanding the *Extended Producer Responsibility* to include the collection of WEEE from consumers' homes. This may incentivise collectors to be more careful in handling EEE, while simultaneously allowing the goods to be inspected before it is treated as waste. For such a system to work, the collectors must have the necessary competence to assess the condition and applicability of products. Moreover, it requires that collectors and consumers coordinate collection (time and location). This is probably considered a significant financial change and commitment compared to the current system. It is thus critical to find a balance on how much the producers will cover versus consumers or government subsidised waste collection.

Overall, the process of determining whether EEE is feasible for reuse is dependent on sufficient understanding and coordination on standards-setting. This is applicable in all future pathways in policymaking and CBMs. This thesis highlights the importance of system simplification by collecting data throughout the EEE life cycle. For instance, EEE might be given a unique ID that displays prior ownership and maintenance history, like a car's service book. This is already in progress in the EU with the proposal for a *Digital Product Passport "*to electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers" (European Commission, 2022). This could enhance wide stakeholder understanding of what is required to resell a used product. In other words, a rigorous database and standard-setting can lead to increasing education on the value of reuse and ultimately induce an increase in pro-environmental behaviour in the EE industry. Lastly, it is also likely that this might incentivise consumers to take better care of their products as they can both sell and purchase products of a certain quality. Such a measure may increase consumer trust in second-hand products.

By increasing consumer trust and thus attractiveness of reused EEE, this thesis argues that it is more likely that the market will experience a speedy deployment of reuse practices, CE designs and ultimately higher reuse rate. Consumers are becoming more environmentally aware, and thus such trust can lead to the increasing demand for alternative products (such as reused EEE). Whilst the change in demand is important, it is equally important with sufficient and easy supply. Hence, the presentation of reused EEE at retail stores is considered key in making them more appealing, which may induce the market transition. In addition to lowering prices, as previously discussed, the retailers should offer guarantees. These should assure that the products are of a certain quality, and cover repairs and replacement if product failure occurs (e.g., within a 2-3-year period). This would contribute to easing the consumer scepticism of second-hand products, and consequently strengthen the demand for reused products.

This section has highlighted the key implications of the results presented in section 6.2. This was carried out by presenting several recommendations directed at solving the barriers to reuse. Yet, it is important to note that other recommendations could have been included such as education of skilled labour (e.g., technicians) or changes in warranty policies. The latter is also correlated with the need for increased awareness of such policies amongst consumers. However, this section emphasised the recommendations that were deemed wide-reaching and instrumental to increase the reuse rate.

7. Conclusion

This thesis' has explored how different stakeholders could contribute to increasing the reuse of EEE in Norway. By examining previous literature on reuse, circular economic principles, and expert interviews, the thesis presents insights into the status quo of the Norwegian EE industry and identifies barriers to reuse.

The findings indicate that reuse is becoming prevalent amongst several key Norwegian stakeholders. Both retailers and municipalities are collecting EEE for reuse, a country-wide approval scheme for consumer electronics is emerging, and consumers are more concerned with environmental issues and thus surveying alternatives to the current culture of consumption. Yet, it is clear that salient barriers are preventing the wide adoption of reused EEE. The expert informants, representing four value chain stakeholders, recognised and emphasised a wide range of challenges in adopting reuse. For instance, the reuse and repair of EEE are still not economically sustainable and higher competence and skilled employees are required. Furthermore, consumers are sceptical and regulatory ambiguity is present. Yet, the barriers to the reuse of EEE are comprehensive and do not differ at national borders. For instance, the current EEE is characterised by linear design whereby products are not repairable, spare parts are scarce whilst producers and retailers lack incentives to implement CBMs. Thus, the findings indicated a need for collaborative efforts in promoting reuse wherein *Policymakers, Producers, Retailers, Workshops, Consumers*, and *Waste Management companies* should all participate actively to induce change.

For producers to redesign their products to adhere to circular principles, regulations and incentives are required. Moreover, the processing costs (i.e., spare parts, repair, cleaning, and verification) need to be reduced if the price of reused EEE is to become competitive. The thesis argues that VAT reduction and financial subsidies for companies contributing to reuse will assist in lowering these expenditures. As a result, reused EEE should become more attractive for consumers, conditional on an appealing presentation with satisfactory warranty rights. Another important consideration is that products must be recovered before it becomes waste. For instance, the *Extended Producer Responsibility* could be expanded to cover the collection of EEE from consumer homes. Moreover, the handling, monitoring, and sorting at reception centres must be improved to better detect whether goods are functioning, repairable, or disposable. This could be executed with better and centralised data collection. Data collection and standard-setting can also result in educating consumers to improve their handling of EEE to retain the value, which might both increase consumer trust and awareness of the reuse market potential.

Due to the scope of this thesis, there are aspects which should be explored further. Future studies should examine the environmental benefits and political feasibility of the suggested measures. Moreover, there is a need to identify the available technical solutions for effective production and repair. This might be particularly important in an international context and comparison. In other words, future studies should aim to discover levers for success in cross-country analyses and apply such learnings to the Norwegian market. As this thesis solely focused on the prospect of identifying and overcoming barriers in Norway, such complementary and future findings might be key to influencing policymaking for reuse and innovation in production.

To summarise, regulatory measures, incentives, and cultural shifts are key to achieving ecosystem circularity in the EE industry. The thesis' suggestions aim to contribute to overcoming the identified barriers to reuse in the Norwegian EE industry. Note that the findings reflect a preliminary review of the current state of the EE industry as regulation is continually changing. Yet, the research can be utilised by industry stakeholders and policymakers as indicative findings to assist in establishing what effective collaboration looks like and how Norway can become the pioneer in the reuse of EEE.

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8. Appendix

Appendix A: Interview Guide

Introduction	– An informal conversation about the researcher’s and informant's background – Present the purpose and structure of the interview – Clarify that the interviewees will be anonymised and ensure the consent of audio recordings if applicable
Status quo	– What characterizes the business model in the electronics industry? – Can you tell us about the life cycle of EEE in Norway? ▪ In 2021, 1.8% of EE waste was prepared for reuse. What does this mean in practice? ▪ Have you assessed the potential of data and digital solutions? – How does interaction and knowledge exchange regarding reuse appear across the value chain? – In recent years, attention toward reuse and labelling of recycled materials has arisen in the clothing industry. Is there any similar attention to reuse and labelling in the electronics industry? – Which product categories have the greatest potential for reuse, and why? – How and to what extent are components reused? – EEE are becoming increasingly advanced and compact in design. Are waste management facilities and workshops able to keep up with the technological development?
General drivers and barriers	– What are the main challenges the electronics industry is facing if we were to increase the share of reuse? ▪ Which stage in the product life cycle do you think has the greatest potential to increase reuse? ▪ Who has the main responsibility for increasing reuse?

	– What can be done to better facilitate reuse: ▪ Before the product reaches the customer? ▪ In the In-use phase? ▪ After the product has been in use? – Which infrastructure is necessary to better utilize the potential of spare parts and discarded electronics? – Do you see any financial opportunities related to more circular products and service activities (e.g. reuse, sharing, leasing/renting)? – How do you think the industry will change in the future?
Consumer behaviour	– Have consumers' attitudes towards reuse changed in recent years? If so, how? – Products are constantly being improved and updated. How does this affect consumers' buying habits? – How can consumers increase the level of reuse?
Policy	– What legal obstacles do we face concerning reuse? ▪ How would you change current regulations to increase the reuse of products and spare parts? – The EU's new action plan for a circular economy promotes a "right-to-repair" and addresses initiatives specifically targeting Electronics. ▪ How do you think this will affect the electronics industry? ▪ How will this affect the economic potential of reuse? ▪ It also addresses universal design. How can this accelerate component reuse? – Is there any distinction in the Norwegian Waste Regulations between the prioritisation of material recycling and reuse?
Summary	– If you were to pull out three of the most important topics we have talked about, what would they be? – Is there anything more you want to add?

Appendix B: Total Revenue (2016-2021)

TOTAL REVENUE NORWEGIAN CONSUMER ELECTRONIC MARKET (1000 NOK)						
	2016	**2017**	**2018**	**2019**	**2020**	**2021**
Audio and video products including photo	6 484	8 096	6 734	6 827	8 596	8 390
Household electrical appliances	10 635	10 616	11 206	11 380	12 409	13 225
PC/gaming/home office/smart home	4 340	4 030	4 007	3 878	7 500	7 725
Mobile Phones + Tablets	10 500	11 065	11 739	11 825	11 656	11 972
Wearables	1 196	1 450	1 754	2 120	2 197	2 335
Total	33 155	35 257	35 440	36 030	42 358	43 647

Compiled from (Elektronikkbransjen, 2022a)

Appendix C: Recovery rates 2021

	Product category	Required recovery rate	Required recycling and reuse rate	A WEEE recycled (tons)	B WEEE prepared for reuse (tons)	C WEEE energy utilised/ recovered (tons)	D WEEE processed (tons)	E = (A+B+C)/(D) Recovery rate (%)	F = (A+B)/(D) Recycling and reuse rate (%)	G = (B)/(D) Reuse rate (%)
1	Temperature exchange equipment	85	80	19 190	464	2 786	22 882	98,07	85,90	2,03
2	Screens, monitors and equipment containing screens with a surface greater than 100 cm²	80	70	4 903	921	417	6 575	94,94	88,59	14,01
3	Lighting equipment	0	80	1 108	0	0	1 165	95,06	95,06	0,00
4	Large equipment (external dimensions more than 50 cm)	85	80	31 732	341	4 236	38 130	95,22	84,11	0,89
5	Small equipment (no external dimension more than 50 cm)	75	55	23 681	22	4 284	29 461	94,99	80,45	0,08
6	Small IT and telecommunication equipment (no external dimension more than 50 cm)	75	55	6 032	649	1 224	8 321	94,99	80,29	7,80
	Total	**0**	**0**	**86 646**	**2 398**	**12 947**	**106 535**	**95,73**	**83,58**	**2,25**

	Examples of products included in respective categories
1	Refrigerators, Freezers, Air conditioning, Heat pumps
2	Televisions, Monitors, Laptops, Notebooks
3	Fluorescent lamps, High intensity discharge lamps, LED
4	Washing machines, Audio and video video equipment, Electric stoves
5	Vacuum cleaners, Microwaves, Electric shavers, Watches
6	Mobile phones, Routers, GPS, Calculators

The figures illustrates the recovered quantity of WEEE in 2021. Note: The data only applies to EEE collected through WEEE compliance schemes. In addition, the figures are not exclusively related to consumer electronics-

Product category 7 and 8 (*Large industrial equipment* and *Large industrial cables*) were excluded from the list as it does not account for consumer electronics. The total reuse rate increased from 1.8% to 2.03% as a result.

Data on WEEE was retrieved from (Miljødirektoratet, 2022b). Examples from each product category were inspired by (Avfallsforskriften, 2004, § 1-1a).