Utrecht University

Master's Thesis

Sustainable Business and Innovation

Evaluating the Dutch WEEE System transition to CE 3.0: Maximising products value retention with a focus on ICT product category

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Abstract

Developed countries have achieved significant results for waste management by the implementation of Circular Economy (CE) principles. Legislative proposals that promote higher efficiency on waste prevention and management provide better alternatives to the "take-make-dispose" model. The Netherlands is considered a frontrunner country on the application of CE principles on the waste framework. However, the country has focused on material collection and recycling, still relying on practices promoted by CE 2.0 principles. The Dutch WEEE System transition to adopt CE 3.0 principles can stimulate consumption reduction, materials reuse and strategies that encourage materials' higher value retention.

Therefore, this study analyses how the current Dutch WEEE System, focusing on the product category ICT, can be improved to focus on products and materials towards higher value retention options, including reducing resource inputs and prioritizing shorter loops. This research's methodology consists of evaluating the WEEE policies and its translation into the Dutch WEEE operational system, as well as verifying system's compliance with CE principles. Furthermore, stakeholders' opinions about the system are also considered. However, based on the multi-level perspective (MLP), socio-technical configurations influence the successful adoption of higher value retention activities by the WEEE System. The data analysis is based on literature review, WEEE legislation at EU and Dutch levels and stakeholder interviews.

Hereafter, as a result, this research proposes four measures to promote higher retention options in the WEEE System: (1) a clear definition of circular actions; (2) officially recognising all the stakeholders present at the system, such as repair cafes; (3) requiring information reports from all stakeholders involved in any circular action; and (4) establishing targets for other circularity actions besides recycling and recovery.

Improvements regarding the legislation and system's process considered the challenges imposed by socio-technical factors that influence the WEEE System. Financial incentives to promote circularity actions, promotion of business models, and consumer's responsibility are economic and social factors that can act as relevant barriers to the Dutch WEEE System fully transition into the adoption of CE 3.0 concepts.

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Abbreviations

B2B	Business to business
CE	Circular Economy
DfE	Design for environment
EEE	Electrical and electronic equipment
EoL	End-of-life
EPR	Extended Producer Responsibility
EU	European Union
ICT	IT and telecommunications
MLP	Multi-level perspective
MS	Member state
NVMP	*Nederlandse Verwijdering Metalelektro Producten*
NWR	*Nationaal WEEE Register*
PCs	Personal computers
PoM	Placed on the market
PRO	Producer Responsibility Organisation
PSS	Product-service system
WEEE	Waste of electrical and electronic equipment

1. Introduction

1.1 Waste of electrical and electronic equipment (WEEE)

The increasing consumption of electrical and electronic equipment (EEE) has become a concern for governments in recent years. In the Netherlands, the growth of EEE sales was 59% between 2014 and 2018 (National WEEE Register, 2019). However, incorrect WEEE treatment and handlings, such as inappropriate waste disposition in dumpsites and the processing of materials recovery highlight concerns about the criticality of promoting a correct WEEE management (Gidarakos, Basu, Rajeshwari, Dimitrakakis, & Johri, 2012; Ongondo, Williams, & Cherrett, 2011; Wong et al., 2007).

Developed countries have achieved significant results in waste management by the implementation of Circular Economy (CE) principles (Ghisellini, Cialani, & Ulgiati, 2016), while legislative proposals help to promote higher efficiency on waste prevention and management (Bourguignon & Bonafè, 2018). One example is the Circular Economy Package (European Commission, 2015), promoted by the European Union (EU), in which the Netherlands is a member.

The concept of Circular Economy is a development model that can lead sustainable development, providing a better alternative to the current dominant model of "take-make-dispose" (Ness, 2008). This study uses the CE definition introduced by Kirchherr, Reike, & Hekkert (2017): "*an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes*."

An instrument to promote WEEE management applying CE principles is the Extended Producer Responsibility (EPR), in which the responsibility for products' entire life-cycle is extended to producers, following the polluters pay principle (Lindhqvist, 2000).

1.2 Problem definition

The CE concept has been evolving over the years (Blomsma & Brennan, 2017; Reike, Vermeulen, & Witjes, 2018). Reike et al. (2018) present CE's evolution by distinguishing its three phases. CE 1.0 promoted management mechanisms to deal with waste, mainly focusing on output measures by not preventing waste but limiting pollution. CE 2.0 focused on promoting a stronger integration, considering preventive and output measures in a way to benefit environment and business activities.

EPR policy promotes responsibility sharing between business and government over products' end-of-life (EoL) management. When initially applied, the idea was to use a framework to deal with waste and resource management, and policymakers started to use circularity as a legislative tool (Blomsma & Brennan, 2017). Currently, CE 3.0 deals with resource depletion and value retention challenges through narrowing material loops. It takes into consideration a holistic perspective, viewing CE as a regenerative system.

The Netherlands is considered a frontrunner country on the application of CE principles on the waste framework, showing good results on recovery rates (Ghisellini et al., 2016; Reike et al., 2018). Such position places Dutch policymaking as a leader that should be taking the next steps to adopt better CE actions (Reike et al., 2018). However, despite CE's evolution, its translation into practical actions is not equally high (Kirchherr et al., 2018). The country has historically focused on material collection and recycling, still relying on practices promoted by CE 2.0 principles. The implementation of further steps that stimulate consumption reduction, reuse of materials, and strategies that encourage materials' higher value retention is still deficient.

1.3 Study relevance

Scholars highlight the necessity of promoting a systematic shift that directly connects the different attributions related to CE and waste management (Ghisellini et al., 2016; Kirchherr et al., 2017). It is necessary to analyse how the waste management system can further incorporate reuse, repair and refurbish activities. Moreover, it is necessary to consider the impact of regulatory instruments as a driver to promote change. Little is said about how to enhance policies to comply with strategies that go beyond a narrow focus on recycling, but also frame the complete CE concept, in which materials and products are reused, refurbished and recovered to keep resources in use for as long as possible.

When focusing on WEEE, most of the studies (Defillet, Cosyn, & Vanderschaeghe, 2013; Ongondo et al., 2011; Yoshida & Yoshida, 2010; Zoeteman, Krikke, & Venselaar, 2010) are still concentrated on presenting reviews of the different schemes applied to WEEE management and on practices to increase collection rate and on recycling improvement. As Islam & Huda (2018) verified, there is a lack of literature about the integration of other CE alternatives, beyond recycling, on the WEEE management system.

Therefore, this study's relevance comes from the necessity to analyse how current Dutch WEEE System can transition from CE 2.0 to CE 3.0, fostering strategies that focus on products and materials value retention, reduction of resources input and prioritize shorter loops activities.

1.4 Aim of this study

This thesis aims to critically examine the current Dutch WEEE system's performance and evaluate how to promote higher value retention of products and materials based on CE 3.0 principles. The research considers a multi-level perspective[1] (see section 3.1) approach and focuses on IT and telecommunications (ICT) equipment, as justified in section 2.5.

Hence, the following research question is considered:

> *How can the Dutch WEEE System, in the case of product category ICT, transition to CE 3.0 through promoting the higher value retention of products?*

To guide this research, two sub-questions are proposed:

> SQ1: *How is the Dutch WEEE System currently organised?*
>
> SQ2: *What socio-technical factors act as barriers on the Dutch WEEE System transition to CE 3.0?*

This thesis is structured as follows. Chapter 2 presents the WEEE problem background, the creation of EPR, and its application in the Netherlands. Chapter 3 presents a literature overview of how the system considers the multi-level perspective on transition theory, the retention of values resources through CE, and the socio-technical barriers the WEEE Management System needs to consider on the transition into the adoption of CE 3.0 principles. Chapter 4 addresses the methodology applied in this research. Chapters 5 and 6 focus on evaluating the current Dutch WEEE System and the socio-technical factors that influence it, answering the sub-questions 1 and 2. Chapter 7 will revisit the research discussion by showing the its limitations and derived recommendations. Chapter 8 concludes the study.

[1] The multi-level perspective is used by Geels (2002) to study technological transitions and comprehends three levels: niche, regime, and landscape.

2. Promotion of WEEE Management

2.1 Problem Background

The correct EoL management of WEEE brings the contamination avoidance of soil, groundwater, and people as the main challenge. Additionally, several materials found in EEE are considered scarce or critical. EEE contains a significant amount of precious metals with limited geological availability, generating its scarcity. The criticality occurs when these scarce materials are under potential supply constraints due to production concentration in a few countries. On the supply and demand perspective, a supply dependence may occur in this condition, since materials' substitution is difficult due to specific properties (Ayres & Peiró, 2013).

A second factor reinforces the necessity of further promoting WEEE management. Although most European countries have an established waste management system, with a proper collecting structure and existing WEEE regulations, their capacity to process waste is not enough. The lack of capacity to process the waste or even financial reasons (lower costs) generate WEEE transboundary to other locations in both legal and illegal ways (Basel Action Network, 2018). The leakage of materials to developing countries, especially in Africa and Asia, produces a problem transfer, forwarding the challenge to perform proper waste management (Seager, Hieronymi, McIntrye, Guilcher, & Janse Van Rensburg, 2012). With its long-established low labour costs and not stringent environmental laws, China became a common destination to the exporting of WEEE from the EU (Yang, Lu, & Xu, 2007). However, China has been working on its legislation to strengthen earlier regulations and forbidding WEEE importing (Ongondo et al., 2011).

2.2 The instruments to enhance the WEEE management

By 1990, Thomas Lindhqvist started to consider an instrument to improve products EoL management, introducing the EPR concept as a policy strategy (Lindhqvist, 2000). The concept aimed to address waste management responsibility to producers over the previous understanding that waste should be in charge of consumers and authorities.

"EPR is a policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling, and final disposal of the product." (Lindhqvist, 2000)

Emerging simultaneously in Austria, Germany, the Netherlands, Switzerland, and the Scandinavian countries (Lindhqvist, 2000), the concept becomes widespread. From 1990 onwards, many States have been working on legislation that focuses on improving waste management. Considering the EU, the establishment of the WEEE Directive based on the EPR concept occurred in 2002. The WEEE Directive 2002/96/EC (European Parliament, 2003b) (hereafter: 2002 WEEE Directive) concerns about WEEE collection improvement, treatment, and recycling, supporting the creation of schemes where consumers can return their WEEE for correct EoL treatment, separating these products from conventional households waste streams. In the following years, amendments were implemented during directive revisions, aiming to increase the promotion of the CE principles and stringent targets, as further analysed in section 5.1. The recasts were Directive 2012/19/EU (European Parliament, 2012) (hereafter: 2012 WEEE Directive Recast) and the 2018 WEEE amendment (European Parliament, 2018).

2.3 The EPR policy

EPR policy has the primary goal of promoting responsibility acceptance by producers and importers regarding financial or physical aspects for the treatment or disposal of post-consumer products (Lindhqvist, 2000).

However, to extend EPR responsibility acceptance to EEE producers is not simple. Financial benefits concerning products' EoL are not evident to electronics producers and importers since the process is seen only as a cost factor in the production (Zoeteman et al., 2010). Therefore, it requires government intervention to enforce legislation addressing actions concerning the problem of maintaining hazardous materials away from the regular waste stream and promoting its correct disposal and treatment.

Based on the WEEE Directive, EU countries established their EPR policies. One of its main characteristics is that each member state (MS), in their legislation, is responsible for implementing the WEEE EPR principle and regulating its operational aspects. Countries' autonomy for policy creation allows different behaviours regarding the process of implementing the legislations and their enforcement approaches (Monier et al., 2014). The way producers deal with EPR obligations varies in many aspects, such as the adoption of individual and collective actions, the level of producers' responsibility regarding costs and take-back logistics, and consumers' integration as responsible for returning the WEEE into the collecting system.

Countries that rely on collective schemes, such as the Netherlands, Belgium, and France, make use of an organised institution to coordinate the entire EPR process: the Producer Responsibility Organisation (PRO).

2.4 The Producer Responsibility Organisation (PRO)

The way producers and importers choose to fulfil the obligations can be either individually or by joining a collective scheme.

Usually, most producers are involved in collective take-back systems arranged by the PRO to handle the requirements expressed by the EPR (Walls, 2006). PRO's primary functions are related to managing WEEE collection and treatment, being financed by fees paid by producers and importers. Moreover, with the increasing WEEE growth, PRO also started to have a more prominent role, promoting higher intervention on operational aspects and communications campaigns, for example (Monier et al., 2014).

Nevertheless, much discussion has been happening about the trade-offs between collective and individual take-back systems. Individual systems facilitate more direct incentives to promote enrichments on WEEE prevention and treatment, such as the design for environment (DfE). On the other hand, collective systems are easier to be monitored by the government, promoting an economy of scale (Walls, 2006).

In the Netherlands, producers and importers can choose between joining the collective system or having and individual system. The Nederlandse Verwijdering Metalelektro Producten (NVMP) Association manages the Dutch WEEE PRO. Six product foundations collectively advocate the association that is involved in the WEEE regulation and legislation. The foundations are Fiar CE (white and brown goods), ICT Milieu (IT and telecommunications), LightRec (lamps and luminaires), Metalektro Recycling – SMR (boilers, toys, medical equipment, vending machines and musical instruments), SVEC (tools) and Witgoed (kitchen appliances). Manufacturers and importers are under the foundations that detail each product type's responsibilities and combine forces to attend NVMP interests. The operational implementation of the NVMP is in charge of Wecycle. Figure 1 represents the NVMP organogram.

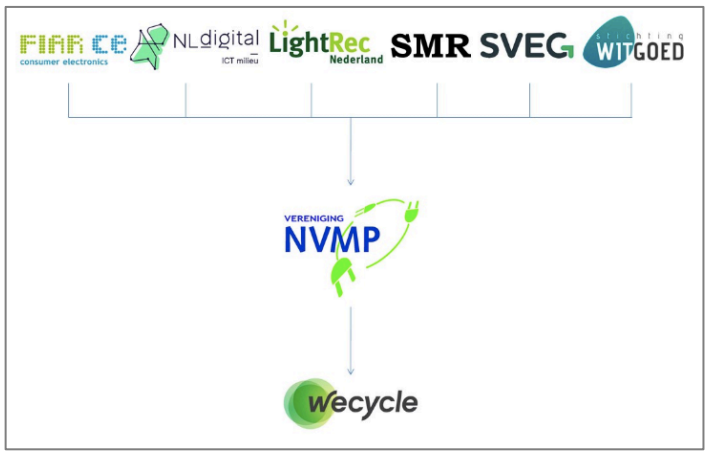

Figure 1: NVMP organogram ("NVMP Association," 2019)

The system's operational perspective is to ensure the maximum WEEE collection and promote an adequate destination to it. NVMP relies on improving the WEEE collecting rate and reclaiming materials for recycling or energy generation (Figure 2). There is a priority on the application of technical output measures but little effort is addressed to materials' use reduction or innovation.

Such measures are compatible with CE 2.0, in which environmental problems are seen as economic opportunities, promoting results regarding longer loop value retention (Reike et al., 2018). However, these activities are the last sustainable options to be considered, proving lower returns in efficiency and profitability.

Therefore, despite the association's ultimate goal being the generation of closed electronics cycles ("NVMP Mission," 2019), following the EU WEEE Directive of promoting a higher circularity in the WEEE system, limited actions are currently in place to achieve this goal.

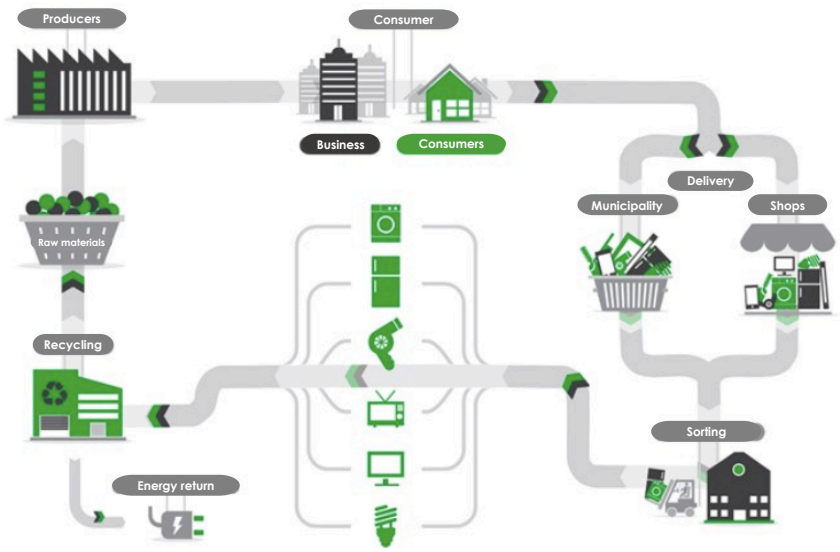

Figure 2: NVMP collecting system structure ("NVMP Structure," 2019)

2.5 The ICT category

Considering WEEE product's different characteristics, such as functionality and recycling perspectives, the WEEE Directive divides WEEE in distinctive product categories. The 2002 EU WEEE Directive separated e-waste into ten different collection categories (Appendix I) (European Parliament, 2003b). However, the 2012 EU WEEE Directive Recast stated a change, putting in place a new division of six categories (Appendix II) after 15 August 2018. Section 5.1.1 further explain such changes according to the evolution of the Directive policies and the impacts on the EEE categorisation.

For this study, a focus on the IT and telecommunication equipment, commonly known as ICT, is given. Considering the categorisation placed until 15 August 2018, ICT corresponds to category 3. Although some changes occurred after 2018, this study relies on the prior categorisation since stakeholders are still adapting to the most recent process in 2019/2020. Furthermore, most of the WEEE information and stakeholders still consider the previous categorisation.

Factors such as weight, economic value, and environmental relevance place desktop PCs, notebooks, tablets, and mobile phones as the main products of category 3. Balde et al. (2017), highlight two main reasons for the importance of the ICT product category. First, information exchange by using technology is globally rising, leading to an increasing number of mobile network and service users. Second, the products have a high replacement speed. Technological advances bring innovation and efficiency, generating faster replacement cycles for ICT devices, as shown in Figure 3.

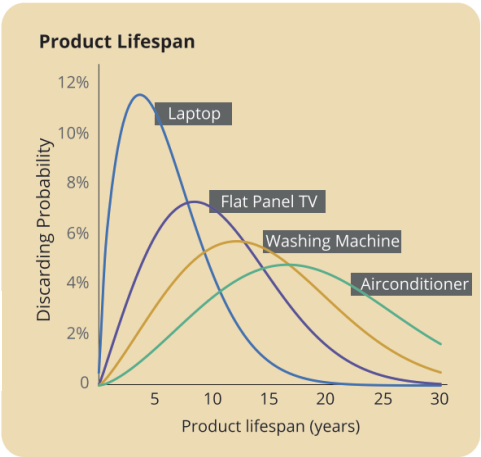

Figure 3: EEE Lifespan (*Balde et al., 2017)*

Many EEE discard occur before the equipment achieves a complete lifespan. Cox et al. (2013) describe that two consumer's expectancy bases influence product's lifetime: its nature (durability), and 'nurture' (willingness to keep it). They acknowledge that products are discarded before broken, and the reasons for that are both design and functionality. Nevertheless, emotional and rational reasons comply with constant products' updates since it reflects a feeling of success in life.

Even when they are still functional, the fast rotation of new products highlights the necessity to provide alternatives to discard, such as refurbish and reuse, once many of the products might be just outdated (Balde et al., 2017). Therefore, the necessity to consider other management options that offer higher finance and energy use benefits is proven.

3. Theoretical perspective: transition process and CE 3.0

The problems CE can address are attached to a previous view that business proactiveness brings efficient promotion, and addressing responsibility to the polluters creates a suitable environment that fixes the current production-consumption problem (Tong & Yan, 2013). The "win-win" strategy considers waste generation as a valuable output. However, such a view does not recognise societal threats, as planetary limits. The current exploitation of resources mode is not viable, requiring the transition into the CE principles (Reike et al., 2018).

It becomes necessary to slow, reduce, and close resource cycles. However, the participant actors (academics, producers, consumers, government) have different opinions about the real CE goals and evolution. The different outcomes expectations lead the actors to differ in realizing their role and level of influence in the system (Blomsma & Brennan, 2017).

3.1 Promoting transition through MLP

As Geels (2002) argues, transitions do not only involve technologies but also changes in regulation, infrastructure, and culture, resulted from social group activities. In this case, transition theory is considered a type of reflexive governance in which cooperation and involvement of actors and their knowledge are needed (Lauridsen & Jørgensen, 2010).

The MLP framework can be an analytical tool used as guidance towards the improvement of circular strategies. The framework is composed of three different levels, in which the first presents innovation niches. The level accounts for the generation and development of changes, considering product innovation through R&D, supply-chains, and producer-consumer relationships, fostering the learning process. Innovation trajectories are situated in a socio-technical landscape, consisting of structural trends, including economic growth, political ideologies, cultural and normative values, and environmental problems. This level consists of slow-changing external heterogeneous factors. While the landscape is an external structure or context for actors' interactions, the regime level refers to rules that enable and constrain activities. The regime level accounts for the development of stability, guiding innovation towards incremental improvements. Practices and process rules are settled, as corporate governance structures. This set of rules is carried by different groups influenced by policymakers, producers, and societal groups.

Geels (2002) describes the link between these levels (Figure 4), considering that innovation does not occur only by changes at a specific niche. An alignment of developments supports

long-term changes, in which changes at the regime and landscape-level are necessary to settle the innovation processes.

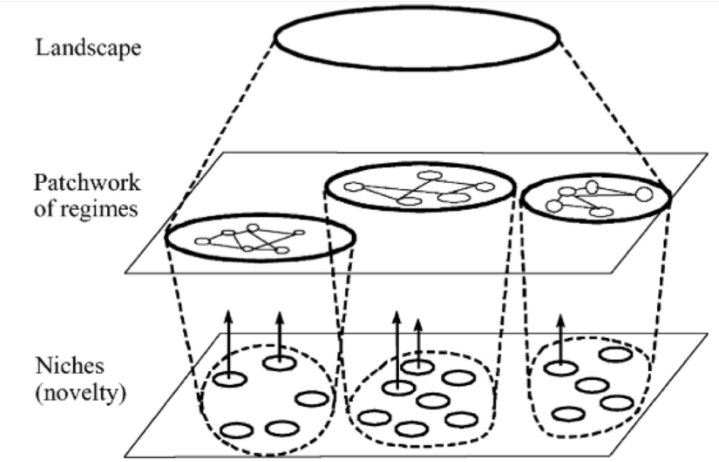

Figure 4: Multi-level perspective (*Geels, 2002*)

Considering the MLP perspective, the transitioning of the WEEE Management System to promote higher value retention of products and materials deals with several barriers. The weak promotion of an innovation-oriented regime in the WEEE policies is an example of it (Lauridsen & Jørgensen, 2010). Nevertheless, Tojo (2001) still advocates about the importance of legislation, as a communication path between upstream (design of products) and downstream (EoL management).

The problem faced by the WEEE Directive on following both regimes (waste management and sustainable innovation) reflects the conglomerate of interests and agendas that constitute the WEEE initiative. The alignment of stakeholder's goals and expectations is necessary to push change in this complex product chain. There is a necessity to promote a transition in which CE principles become accepted as a full systemic approach, which involves promoting an innovation-oriented view and the already applied cost-effective practices. Lindhqvist (2000) enforces that a systemic view is the EPR crucial element, differentiating it from a mere take-back system. However, the EPR mechanism does not have a structure that easily addresses the system's development.

Therefore, the simplified causal relations between regulations and production can hardly address the complex interactions among various agents at different levels. As Leclerc & Badami (2019) demonstrate in their study in Canada, approving legislation does not guarantee the success of the policy implementation. It is necessary to consider the different levels of

transition, from the firm/product level to regime change in the waste management sector, and the modes of production and consumption of our modern society (Tong & Yan, 2013). Tong & Yan (2013) apply the MLP framework, identifying both regimes that must be considered when promoting the EPR (Figure 5).

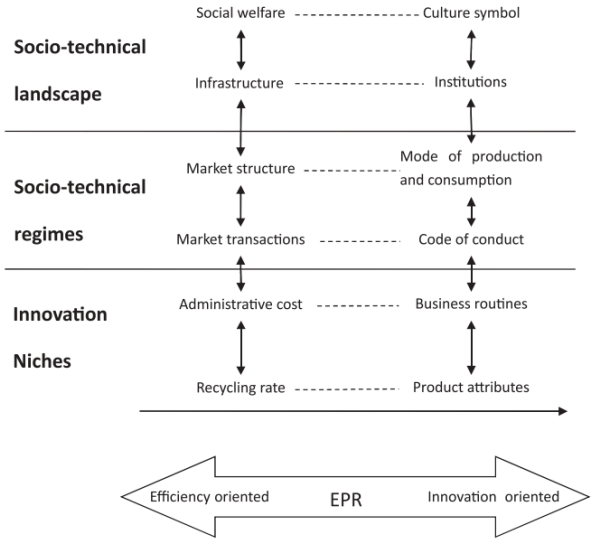

Figure 5: Innovation-oriented versus efficiency-oriented analysis of EPR *(Tong & Yan, 2013)*

3.2 Circular Economy

The evolution of the CE principles goes toward the promotion of innovation regarding environmental concerns (Lauridsen & Jørgensen, 2010). The transition of the CE framing into a third phase acknowledges the retaining value of resources as an alternative to endless consumption and resource depletion threat (Reike et al., 2018).

The promotion of value retention options considers that circularity occurs long before products hit massive production and achieve its EoL. To conceptualize CE, Reike et al. (2018) present a 10R typology (Table 1). The Rs imperatives consider value retention options by prioritizing a minimum of entropy and giving the products consecutive lives. The idea of loops creation is central, considering that short loops maintain the product closer to its user and functionality, while in long loops, products lose their original function (Reike et al., 2018). The differentiation between loops generates diversified interaction since the R-activities can consider relations between consumer-to-consumer, consumer-to-business, or business-to-business (Reike et al., 2018). Therefore, a variety of stakeholders need to be acknowledged as the relevance of different interaction levels.

Reike et al. (2018) describe the loops in three levels, relating it with the stakeholders involved in each interaction. Short loops concentrate on extending the product's life spam. Consumers have an essential role in this level, due to their consumption behaviour. Producers also have a role in the pre-market stage with the concept and design of products that benefit short loops adoption. Plus, extra stakeholders are involved with repair and second-hand shops and sharing economy platforms. Medium loops promote activities mainly connected with the replacement of some components without changing the overall product structure. At this level, businesses are the main stakeholders involved, but it is also possible to see artists' and designers' creations using discarded material parts. Lastly, the long loops connect with traditional waste management activities, focusing on materials reuse for other functionalities than the original, easily relating to the current WEEE System.

Table 1: 10R retention value hierarchy. Adapted from Reike et al. (2018)

	R #	CE concept	Key activity: Costumer	Key activity: Market
Short loops Cliente / users choice	R0	Refuse	Refrain from buying	Promote 2nd life cycle and redsign
	R1	Reduce	Use less, use longer; recently: share the use of products.	Promote 2nd life cycle and redsign
	R2	Re-sell / Re-use	Buy 2nd hand, or find buyer for your non-used produced/possibly some cleaning, minor repairs	Buy, collect, inspect, clean, sell
	R3	Repair	Making the product work again by repairing or replacing deteriorated parts	Making the product work again by repairing or replacing deteriorated parts
Medium long loops Product upgrade	R4	Re-furbish	Return for service under contract or dispose	Replacement of key modules or components of necessary
	R5	Re-manufacture	Return for service under contract or dispose	Replacement of key modules or components of necessary, decompose, recompose
	R6	Re-purpose	Buy new product with new function	Design, develop, reproduce, sell
Long loops Downcycling	R7	Re-cycle	Dispose separately; buy and use secondary materials	Acquire, check, separate, shred, distribute, sell
	R8	Recover	Buy and use energy	Energy production as by-product of waste treatment
	R9	Re-mine	Buy and use secondary materials	Grubbing, cannibalizing, selling (South)/ high-tech extracting, reprocessing (North)

The CE approach is not just a base concept that promotes minimum requirements compliance but a complete system structure (Kirchherr et al., 2017). While the efficiency-oriented analysis generally seeks for infrastructure improvement to promote recycling activities with lower cost and complexity, the EPR can support institutional approaches that promote higher circularity principles throughout production and consumption. Innovation on the niche level can be applied at the WEEE Management System. The promotion of higher retention options can emerge from changes in product attributes, designing for dismantling, ease of repair, and

recyclability. Moreover, the regime changes can lead to new norms for the industry and transition to a more sustainable mode of production and consumption.

3.3 Transitioning the WEEE management to CE 3.0 considering the system's complex interactions

Studies about CE's evolution (Blomsma & Brennan, 2017; Reike et al., 2018) and its limited progress can be connected with a variety of barriers (Kirchherr et al., 2018). The changes that lead to CE principles' adoption occur as a gradient with no single event being the only cause of the transition (Blomsma & Brennan, 2017). A system's transition occurs through the interplay between processes at different levels (Geels, 2007).

As presented in section 3.1, the WEEE Directive still faces problems integrating waste management and sustainable innovation regimes. The policies regarding the WEEE management focus on consumption growth and the efficient promotion of recycling activities, largely promoted on the CE 2.0 phase. The interaction between regimes in a multi-level perspective demonstrates the complexities of promoting transitions and how legislation can deal with conflicting agendas (Geels, 2007). Regarding the WEEE System, both regimes, efficiency, and innovation-oriented, are not competitive but should interact and co-evolve (see Figure 5). However, the Dutch WEEE System already has a stable regime with roles and routines, favourable subsidies and regulations, and institutional arrangements.

Promoting change is not easily achievable. Innovations may remain stuck when facing a mismatch with the existing regime. Therefore, the breakthrough depends on niche-internal drivers, connected with performance improvements, per example. While external landscape developments may create pressure on the regime, tensions may come from changing markets, strategic games between firms, policy changes, or new cultural values (Geels, 2007). In that case, CE changes need to comply with a socio-technical view from industrial, political, social, and economic positions, as stakeholders inclusiveness and value chain integration, consumer's role and conscious consumption awareness, and resource value retention.

As presented in Table 2, CE's second phase reinforces a view of waste as a resource, and the strategies related to this phase are extending the use of resources and preventing landfilling through activities like recycling (Blomsma & Brennan, 2017). The evolution of the CE concept implies a shift from implementing and assessing singular strategies to assessing different circular configurations by integrating activities (Blomsma & Brennan, 2017). The current CE

third phase presents a critique about the lack of clarity regarding resource efficiency targets, which remain focused on recycling.

Table 2: Evolution of CE concepts from CE 2.0 to CE 3.0 (based on Blomsma & Brennan, 2017; Reike et al., 2018)

CE 2.0: Eco-efficiency 1990s - 2010	**CE 3.0:Maximizing value retention** 2010 -
• Stronger integration among preventive and output measures	• Decoupling growth from resource use
• Establishment of Design for Environment (DfE): efficiency through design	• Implementation of preventive measures and circularity hinges on organizational aspects rather than on technical matters: promotion of a regenerative system that minimizes resource input and waste by slowing, closing, and narrowing material and energy loops
• Social elements of innovation and implementation largely neglected	• Consideration of a wider system: inclusive stakeholders perspective (supply chain partners, consumers, NGOs, and government)
• Economic opportunity: efficiency	• Economic gain still stressed

Figure 6 considers the elements that involve the WEEE Management System transition from CE 2.0 to CE 3.0. Waste policies have already established ways of framing environmental problems related to efficient waste treatment. However, as previously presented, such measures do not further consider promoting innovation. As the figure shows, CE 3.0 can lead to innovation in the WEEE Management System by promoting the retention of valuable resources through the application of the 10Rs imperatives and by supporting closer loops interactions. The WEEE policy is a tool that endorses such transition enforcing waste hierarchy and promoting mechanisms that support stakeholders integration. Nevertheless, following the multi-level perspective, effective transitions on the system do not only happen through technical changes. Therefore, the analysis of socio-technical factors that interact with the WEEE System offers an understanding of the challenges of promoting innovations. For this study, economic and social factors were considered.

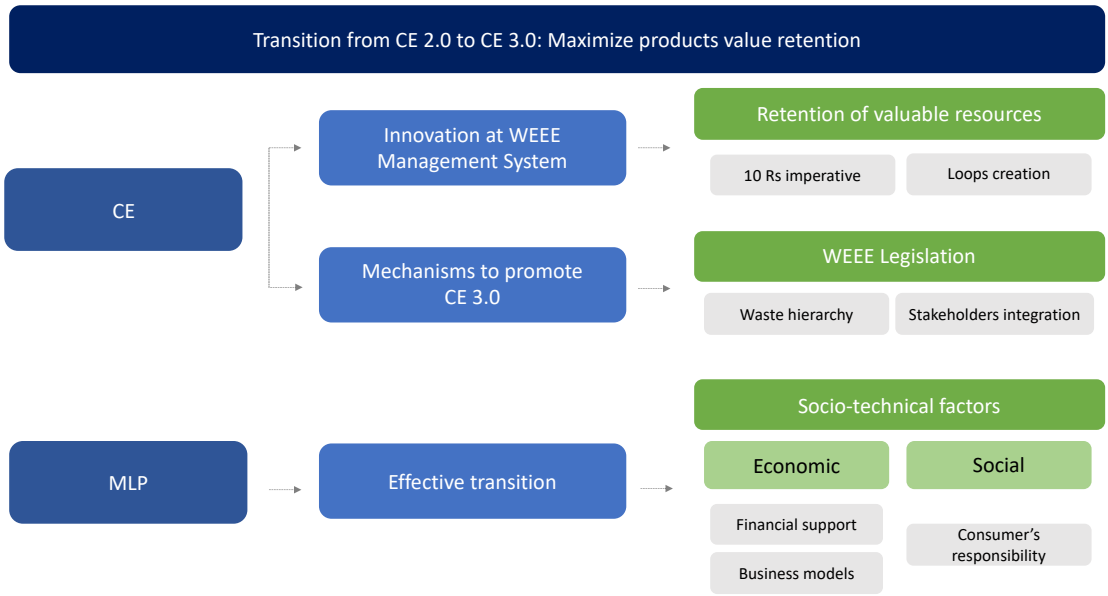

Figure 6: Adoption of CE 3.0 by the WEEE Management System considering the MLP

Three factors can present a barrier to the adoption of the CE 3.0 principles by the WEEE System:

1. **Financial support** is a significant barrier to innovation promotion. It is necessary to encourage stakeholders to act. Geels (2010) argues that actors have no immediate incentive to address sustainability problems. In such a case, public authorities are crucial drivers on the promotion of this transition. Policies need to reframe the economic conditions that will subsequently incentivize private actors to reorient their innovation and commercial activities.
2. Barriers promoted due to financial reasons also impact the development of **business models** that can give closer attention to the waste hierarchy principles. The business models applied to the WEEE System follow the idea of efficiency promotion. Recycling, considering the treatment of large mass flows, is a low-cost solution (Griese, Poetter, Schischke, Ness, & Reichl, 2004), compared with other R strategies. According to Cole, Gnanapragasam, Cooper, & Singh (2019), recycling requires less effort on the collection, with the lower necessity to promote careful handling to retain the potential to promote products reuse. Moreover, the structures regarding recycling have legislative support. The legislation does not enforce the promotion of actions that retain the products' value, causing the recycling of much good quality equipment. The schemes that organise collection and recycling do not consider or support closed-loop

actions, making organisations that support reuse to directly compete with recyclers (Kissling et al., 2013).

Furthermore, the promotion of business models that follow CE 3.0 generates an impact on consumption patterns. Business models based on product-service system (PSS) create more value for clients, at lower production costs for producers and, preferably, lower energy and materials inputs and reduced emissions (Van Halen, Vezzoli, & Wimmer, 2005). Such type of business model is an incentive to promote design that gives higher consideration to the extension of product lifetime, easy repairability, the possibility for refurbishment and materials use (Griese et al., 2004). However, such a business model's promotion involves a cultural change in the consumption pattern, from product-oriented to service-oriented. Most business models still rely on profitability from the selling of consumer goods, with emphasis placed on the volume of items sold (Intlekofer, Bras, & Ferguson, 2010).

3. The third factor relates to **consumer awareness**. Social behaviour is a barrier to the promotion of new business models that aim for closed loops promotion. Consumers should have stronger representation inside the WEEE System and on the role of promoting products higher value retention. Cox et al. (2013), through a consumption lifestyle analysis, realize that products are frequently considered as WEEE before its total functionality loss, due to technology obsolescence or fashionable trends (see section 2.5). According to them, producers and policies might lead to product life extension. Information and infrastructure are two topics that can help consumers make better choices and be proactive in promoting change, since even with consumers proactiveness to collaborate, some barriers still frustrate their effort.

   Furthermore, challenges in promoting EEE life extension and reduce product loops include consumer demand for new products. Whalen, Milios, & Nussholz (2017) present that organisations and consumers want new products, and misconceptions over product reuse and repair have a high influence on the consumer-related barriers to the adoption of actions that promote products higher value retention. Therefore, only focusing on improving EEE durability and repair possibility will not resolve the premature disposal issue. Moreover, specifically for the ICT market, exists a misconception over product reuse regarding quality data security (Balde et al., 2017; Ongondo, Williams, Dietrich, & Carroll, 2013).

4. Methodology

To understand and evaluate the current WEEE system performance and propose improvement points that can lead to the further adoption of CE principles, the following methodology intended to answer the two sub-research-questions (see section 1.4) presented in this research. Figure 7 details the two sub-questions, considering specific scope, method, and outcome, leading to answering the overarching research question.

The sequential steps of this research consist of evaluating the WEEE policies and its translation into the Dutch WEEE operational system, and verify the system's compliance with the CE principles (sub-question 1). However, socio-technical configurations, focusing on economic and social factors, influence CE practices' implementation by the WEEE System. Therefore, the necessity to identify the economic and social barriers to adopt higher value retention strategies (sub-question 2). Hereafter, as a result, this research proposes measures on the WEEE System regarding the legislation and the system's configuration to promote higher retention options, following the Rs retention value typology Figure 5, Table 1) (Reike et al., 2018). Nonetheless, the barriers that influence the WEEE System's development into fully transitioning into CE 3.0 are highlighted.

The research will be based on qualitative analysis. Since the study is somewhat explorative, considering a case study of the Dutch WEEE System, the qualitative approach is suitable to the context of understanding the system. Due to a variety of influences and factors, the effectiveness of the WEEE System cannot have simplified measurements just considering targets achievements. An inside view into the system is necessary to understand the application of and the relationship between WEEE management and the promotion of products higher value retention. Also, this involves a complexity in which explore and analyse actors' interactions and the context they are inserted is essential. The qualitative approaches are also used for studying and comparing perspectives among different stakeholders. Evaluative approaches based on qualitative research recognize the importance of an in-depth understanding of the context in which an intervention occurs and the diverse viewpoints of the stakeholders (Bryman, 2012).

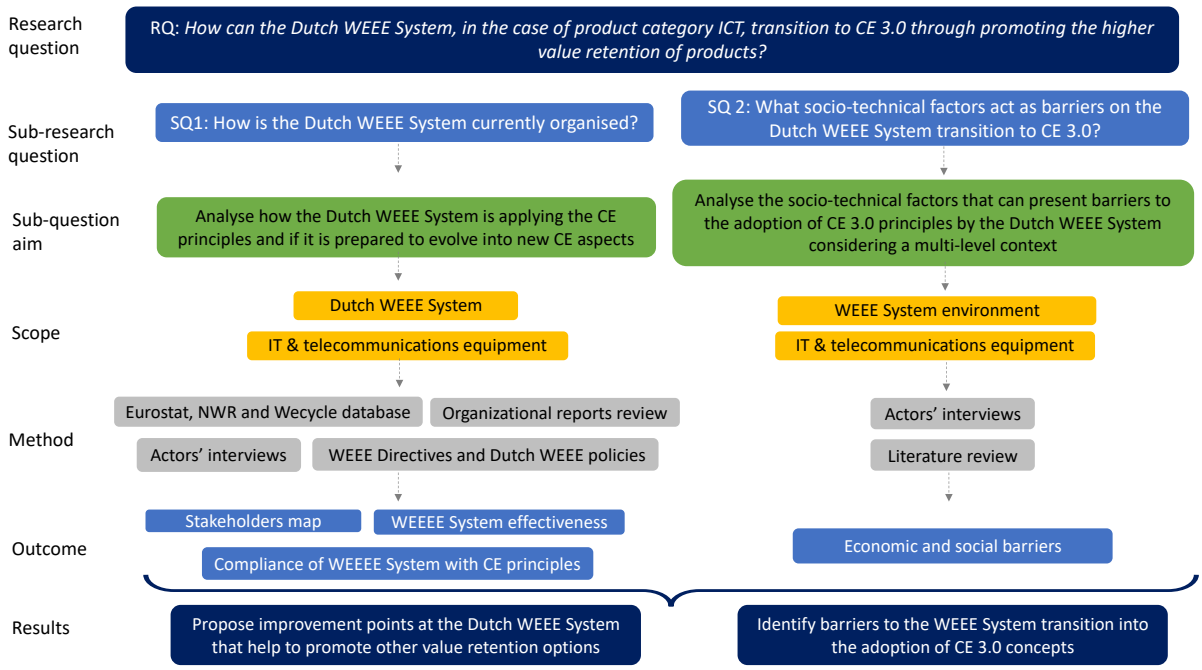

Figure 7: Thesis framework

This research combines policy analysis, interviews, and critical analysis based on the literature (chapter 3) to answer the research questions. Collected data consisted of literature, legislation and organisational reports from OECD, EU, and organisations connected with WEEE Management, as detailed in sections 4.1 and 4.2. Interviews with stakeholders that are part of the Dutch WEEE System were conducted to triangulate evidence found during the document analysis.

The following chapter details the methodological steps: section 4.1 concerns sub-research question 1, and section 4.2 concerns sub-research question 2.

4.1 Dutch WEEE System

Cuppen (2011) sets sustainability issues as a wicked problem, which involves divergent societal stakes and uncertainties. To enhance policy measures is necessary to improve the quality of knowledge about policy decisions considering stakeholders' dialogue and learning through their interactions.

4.1.1 Policy Analysis

To answer the first sub-research questions (see Figure 7), this research began with analysing the EU WEEE Directive and the Dutch WEEE policies. After, the translation of the legislation into the Dutch WEEE operational system was analysed.

4.1.1.1 Data collection

The data collection included documents that concerned the EU's WEEE Directives and associated waste legislation and their Dutch equivalents. Also, grey literature concerning WEEE reports provided by the OECD, EU, and organisations connected with the Dutch WEEE System, such as NVMP, Wecycle and ICT Milieu, were analysed. Data on the technical performance of the system (POM, WEEE generated and treated) was obtained from Dutch registers (National WEEE register), WEEE operators (Wecycle), and National data (Eurostat).

4.1.1.2 Data analysis

The data analysis started with a description and evaluation of the EU legislation, following chronological appearance, regarding WEEE. After, the analysis considered the WEEE legislation implemented in the Netherlands, following EU directions, and establishing the Dutch WEEE System. The Dutch WEEE System analysis considered the authoritative translation into an operational system and the system's efficiency in compliance with legislative specifications and demands (targets achievement).

The organisational reports supported the understanding of the context in which the Dutch WEEE System operates, contributing to presenting the stakeholders involved in the system. The actors involved in the Dutch WEEE System were identified, as their roles and how they integrate with the WEEE System.

4.1.2 Stakeholders' analysis

After the policy analysis, the research followed with the stakeholders' interviews. Interviews were a suitable option to understand the stakeholders' opinions about their compliance with the WEEE System, the system's effectiveness, and to which extend the system is prepared to adopt higher CE strategies. Empirical evidence from the expert interviews helped to clarify the operational perspective of the Dutch WEEE System.

4.1.2.1 Data collection

The data was acquired by six interviews with stakeholders involved at the Dutch WEEE System (Table 3). Professionals were approached considering their diverse responsibilities across the EEE value chain or who can affect WEEE management.

Table 3 shows the interview guideline and the respective stakeholders' role in the system. To raise response chances, different actors that act on similar functions were contacted. Initial contact, either by email or LinkedIn, allowed the researcher to explain the study and extend an invitation to take part in the interviews.

Table 3: Interview guideline

Interview	Focus
Producer	Actions considered to improve/facilitate the EEE circularity
NWR	Data quality and targets achievements
NVMP	Actions regarding the improvements of WEEE treatment and strategies to promote reuse
Wecycle	WEEE collection and operational management
Sorting / Processing facility	Operational mechanisms and material treatment

The response rate was 60%, considering ten initial contacts. Even with not all stakeholders replying to the contact, such conditions did not present a significant impact on the research results. The main goal was to acquire information from stakeholders with different positions inside the supply chain, and such a condition was achieved. However, the non-response of a government representative was a downside of the research since the stakeholder could have provided a more elaborated view about how The Netherlands contributes to the development of WEEE legislation. However, other stakeholders like NVMP have direct interaction with the government and could provide information about the subject.

The interviews presented a semi-structured format via online interaction. A basic script considered a regular set of questions, for consistency and comparable responses, plus adapted questions, focusing on the stakeholder's specific activities (Appendix V). The semi-structured method ensured different observations from each interviewee (Bryman, 2012). The approach provides the necessary flexibility to learn from the interviewee's experience and expertise and allows the interviewee to get into details when considered relevant, establishing a fluid discussion. The significant insights from the interviewees could shape their contribution and lead the debate. At no time did any interviewee refuse to answer individual questions. Furthermore, consent to record the interviews was requested with the guaranty to maintain the

records of the interviews confidential. Also, due to confidentiality, interviewees were not personally identified, but only the organisation they represent.

4.1.2.2 Analysis of the interviews

Each interview lasted approximately 40 minutes and was audio-recorded, transcribed, and coded. The data analysis process involved generating codes at different levels, identifying common themes, responsibilities, interests, and perceived challenges. The codding process allowed to obtain the evidence and opinions necessary to enable a thorough investigation across the sector and establishing complementary and contradictory views and requests.

The stakeholder's operational and active position empowered them with relevant opinions about the system's efficiency and adequate attendance of EPR expectations. The goal was to understand how stakeholders perceive their responsibility and impact, how the CE concept is understood and applied, and the barriers to promoting improvements considering further application of CE principles, enhancing products' higher value retention, and targeting higher levels of the waste hierarchy.

The semi-structured interviews allowed the interviewees to provide their opinions freely, without much direction from the researcher. The proposed questions intended to explore, deepen understanding, clarify the stakeholders' opinions, reduce subjectivity, and provide acceptable validity (Yin, 2003). Furthermore, multiple sources of evidence (Yin, 2003) provided information for this research, from the organisational reports and legislation to the interviews, contributing to the validity.

Regarding reliability, the interviews conducted for this thesis followed a prepared questionnaire. Furthermore, all interviews were recorded, transcribed, and reviewed by the interviewees before included in this report. Such steps imply reducing interview effects and other biases by appropriate documentation (Yin, 2003) in which the analysis can be repeated with the same results.

4.2 Socio-technical barriers to promote higher circular strategies

For the second sub-research question, this research promoted a critical reflection about factors that impact the promotion of CE 3.0 in the WEEE system. To enhance the implementation of CE principles, not only a legislative approach is sufficient. It is necessary to evaluate the socio-technical context that the WEEE system is inserted (see section 3.1).

4.2.1 Data analysis

The data analysis considered the findings of sub-question one and a literature review (section 3.3). The literature review included academic papers and organisations' reports about social and economic factors correlated with the WEEE context and the challenges of enhancing the CE principles by including prevention, reuse, and refurbishing on the WEEE System.

To explore socio-technical factors in-depth, a qualitative research approach considered three economic and social relevant conditions that can present barriers to the WEEE System transition.

Despite the literature review already present analysis about financial and social factors that interact with WEEE management, the focus was to connect the literature review with the stakeholders' perspectives, acquired from the results of the Dutch WEEE System analysis and stakeholder interviews. Such a method provided a connection between the general studies about the topic and this research case study.

The analysis started focusing on the literature about financial incentives to promote development, business models, and consumer responsibility. These three points are recurrent topics in literature when analysing the development of WEEE management. After, a critical analysis considered the impact and connection of these factors with the findings from the Dutch WEEE System case study. The primary outcomes from the Dutch WEEE System analysis were the system's efficiency, the integration of repair and refurbish stakeholders on the WEEE System, the promotion of reusing, repairing and refurbishing activities over recycling and energy recovery, the complexities in attending the requirements related to product design, the WEEE value return, and customer's consumption patterns. Hereafter, it was possible to highlight socio-technical barriers applied to the Dutch WEEE System, when considering the transition to CE 3.0.

5. Result 1: Dutch WEEE System - Development, characteristics, effectiveness and stakeholders

To enhance the policy measures and the WEEE System into a process that improves the materials, value retention is necessary to acquire knowledge about the current policy decisions and stakeholders' interactions. Comprehending the existing framework established by the Dutch EPR System is critical after proposing changes that value other circular activities besides recycling and energy recovery.

The Dutch WEEE System is based on the EU WEEE Directive. EU's perception of the importance of waste management led to creating several policies on waste (see Table 5), including the WEEE Directive. Therefore, to evaluate WEEE management's current demands it's necessary first to understand how these policies have historically evolved.

After analysing policy's evolution and specification on the EU level (subsections 5.1.1 and 5.1.2), the same analysis structure is applied on the Dutch level. Both evaluations aim to understand how the Netherlands uses the EU WEEE Directive as a base to implement the Dutch WEEE System, what are the target demands implemented, the system effectiveness and which are the actors involved in it. After section 5.3 analyses stakeholders' view towards the system, including (1) how they perceive their role and (2) their perspective on how to improve the system, as change agents. Lastly, section 5.4 presents the results of this phase of the research.

5.1 The WEEE Regime at EU Level

5.1.1 Policy evolution (1975 – 2018)

Until the mid-1970s, waste was treated as a local matter by MS and legislation concerning problems related to waste disposal was not present. The adoption of the Waste Framework Directive in 1975 (European Parliament, 1975) began the establishment of a waste policy framework that could be applied to all MS. Subsequently, policies regarding waste have continuously evolved.

The first broad communication regarding waste occurred in 1989 with the publication of 'A Community Strategy for Waste Management' (European Parliament, 1989). The document presented five strategic guidelines: prevention; recycling and reuse; optimisation of final disposal; regulation of transport; and remedial action. It also related the principle that polluters

should pay[2], but without addressing further information about the subject. Moreover, despite stating that "*the best way of preventing or reducing any adverse impact on the environment is to recycle or reuse it*"[3], the definition regarding these two approaches was still simplistic. The different actions of recycling and reuse were presented in combination and not in a precise approach. *"Recycling and reuse of waste can take a variety of various forms including regeneration, raw materials and energy conversion."*[4]

In 1996, the EU continued to show concern about conducting developed waste management actions. The European Parliament Resolution asked the Commission to present a review of different policies and actions. The resolution presented, as one of the amendments, a focus on the strategy for waste management, *"whereas neither the Commission communication nor the draft Council resolution reflects a clear EU strategy for reducing the quantity of waste on the territory of the Union and whereas such a strategy is urgently required"* (European Parliament, 1996).[5] The request considered the emerging of a real strategy based on the principles of producers responsibility *"to put forward proposals for legislation on new priority waste streams rather than the plans to use voluntary agreements, and to come forward as soon as possible with the following Directives (...) based on the producers ' responsibility; to apply practically and uniformly the principle of shared responsibility for waste management, by virtue of which all public and private entities must have a role in waste management"*[6] (European Parliament, 1996).

Several Directives regarded different waste streams, such as toxic waste, batteries and plastic. The Directive 2002/96/EC (European Parliament, 2003b) (hereafter: WEEE Directive) specifically focused on WEEE. The WEEE Directive considered preventive actions application, control of environmental damage at the source, and the producers should pay principle.

The landscape in which the WEEE Directive was applied recognised the need for a significant change in the patterns of development, production, consumption and behaviour. The principles were used as a management strategy, considering that reusing products or material should be preferred, acknowledging those as better environmental options. The WEEE Directive also recognised that *"where the generation of waste cannot be avoided, it should be reused or*

[2] Section III, page 5
[3] Section V, page 11
[4] Section V, page 12
[5] Page 241
[6] Page 242, include this page reference in your citation.

recovered for its material or energy."[7] Table 4 presents the definition of each of the waste management approaches. Recovery and disposal present diverse definition options suitable not only for WEEE but also to different waste streams. Matters regarding product design, repair, and disassembly were also available in the WEEE Directive. However, without specific definitions.

Table 4: Definitions of the different strategic waste management approach according to Directive 2002/96/EC (Article 3)

Activity	Definition
Reuse	*"WEEE or components thereof are used for the same purpose for which they were conceived, including the continued use of the equipment or components which are returned to collection points, distributors, recyclers or manufacturers"*
Recycling	*"the reprocessing in a production process of the waste materials for the original purpose or for other purposes, but excluding energy recovery".*
Recovery	*"'any of the applicable operations provided for in Annex IIB to Directive 75/442/EEC"*, see Appendix III
Disposal	*"any of the applicable operations provided for in Annex IIA to Directive 75/442/EEC"*, see Appendix IV

In 2012, a recast of the WEEE Directive was approved. The Directive 2012/19/EU (European Parliament, 2012) (hereafter: WEEE Directive Recast) presented updated targets and made more strict requirements. Furthermore, in 2018, the European Parliament released a new amendment related to the WEEE directive. The Directive 2018/849 (European Parliament, 2018) provided amending for several Directives, including WEEE Directive Recast. The main amend proposed for WEEE regarded incentives for applying a waste hierarchy, as previously introduced on the Directive 2008/98/EC (European Parliament, 2008). The proposal focused on measures to prevent and reduce the impacts on the generation and management of waste in general, not only WEEE. The Directive considered that *"MS shall take measures to encourage the options that deliver the best overall environmental outcome*." Relevant factors considering waste prevention programmes were contemplated, *"MS shall take measures, as appropriate, to promote the re-use of products and preparing for re-use activities, notably by encouraging the establishment and support of re-use and repair networks (...)."* Furthermore, the Directive

[7] Paragraph 3

gave examples of waste prevention measures related to three different topics: generation of waste; design and production and distribution phase; and consumption and use phase.

Table 5 presents a timeline with the policies that presented the waste management development in the EU and for WEEE specifically.

Table 5: Timeline of directives related to waste and specifically for WEEE implemented by the EU

Year	Document	Main topics
1975	Waste Directive 75/422/EEC	Waste framework
1989	A Community Strategy for Waste Management	Strategic guidelines for waste management
1996	Official Journal of European Communities C362	Proposal for implement waste management based on EPR principle and considering WEEE
2002	WEEE Directive 2002/96/EC	Specifically for WEEE, considering all the aspects of waste management such as processes and stakeholders.
2008	Directive 2008/98/EC	Focus on measures to protect the environment and human health by preventing or reducing the impacts of the generation and management of waste
2009	Directive 2009/125/EC	Directive 2002/96/EC complementary recast - Framework for the setting of eco-design requirements for energy-related products
2012	WEEE Directive Recast 2012/19/EU	Directive 2002/96/EC recast – Specifically for WEEE, considering new targets, stakeholders responsibilities and definitions
2018	Directive (EU) 2018/849	Amending Directives 2012/19/EU - Incentives for the application of the waste hierarchy, as indicated in Directive 2008/98/EC

5.1.2 WEEE Policy specifications

The comparison of both legislations (2002 WEEE Directive and 2012 WEEE Directive recast) shows how the concern about the subject evolved. The WEEE Directive Recast presented the evolution of WEEE management and the challenges faced by the second generation of environmental law to comply with a greening economy (Kalimo, Lifset, Atasu, Van Rossem, & Van Wassenhove, 2015). Table 6 shows the changes and new demands presented by the WEEE Directive Recast. It is possible to see a responsibility transition, shifting from mostly

centred on MS to a shared responsibility between MS, producers and consumers. Consumers acquired a higher acting responsibility on the collecting role and the recognition of EEE growth in the market demanded a continued increase in the collecting rates. Besides, actions like information gathering and knowledge sharing became more relevant.

Table 6: Main changes on demands from the 2002 WEEE Directive to the 2012 WEEE Directive Recast

Differences on demands from WEEE Directive to WEEE Directive Recast		
	2002 WEEE Directive	**2012 WEEE Directive Recast**
Notion of collection	> Producers should finance collection from collection facilities, and the treatment, recovery and disposal of WEEE. > Information to users about the requirement not to dispose of WEEE as unsorted municipal waste and to collect WEEE separately. > Member States shall adopt appropriate measures so that consumers participate in the collection of WEEE and encourage them to facilitate reuse, treatment, and recovery.	> Consumers have to actively contribute to the success of such collection and should be encouraged to return WEEE. > Distributors have an important role in the success of WEEE collection (as providing to end-users - and with no obligation to buy EEE of an equivalent type - the free-of-charge collection at retail shops with sales areas).
Increase of collection rate	> Member States shall ensure that a rate of separate collection of at least 4 kg on average per inhabitant per year of WEEE from private households is achieved.	> The setting of ambitious collection targets should be based on the amount of WEEE generated. From 2016, the minimum collection rate shall be 45 % of EEE's average weight placed on the market in the three preceding years. From 2019, the rate to be achieved annually shall be 65 %. > Member States shall ensure that the volume of WEEE collected evolves gradually from 2016 to 2019.
Information and reporting	> MS shall draw up a register of producers and collect information annually on the quantities and categories of EEE put on their market, collected through all routes, reused, recycled and recovered within the Member States, and on collected waste exported.	> To establish whether the minimum collection rate has been achieved, MS shall ensure that information is transmitted free of charge, including: (a) received by collection and treatment facilities; (b) received by distributors; (c) separately collected by producers or third parties acting on their behalf.

		> MS shall ensure that each producer, or authorised representative, is registered and can register all relevant information reflecting that producer's activities. > MS shall collect information on an annual basis on the quantities and categories of EEE placed on their markets, collected through all routes, prepared for reuse, recycled and recovered within the MS, and on separately collected WEEE exported.
Transparency about collecting costs	> The costs of collection, treatment and environmentally sound disposal shall not be shown separately to purchasers when selling new products.	> MS may require producers to show purchasers at the time of sale of new products, collection, treatment, and disposal costs in an environmentally sound way.
Stricter obligations	> MS shall ensure that inspection and monitoring enable the proper implementation of this Directive to be verified	> MS shall carry out appropriate inspections and monitoring to verify the proper implementation of this Directive(a) information reported in the framework of the register of producers; (b) shipments, particularly exports of WEEE; and (c) the operations at treatment facilities.

The establishment of targets became a way to enforce the necessity to increase stakeholders' compliance with WEEE management and to evaluate the Directive's objectives' achievement. Table 7 and Table 8[8] present the minimum target requests applied to the MS, that can propose higher performances. All WEEE categories have targets, considering different goals for each. On the WEEE Directive Recast, the calculation methodology for targets started to consider a new factor, the amount of EEE placed on the market (PoM). This factor is expected to consider the different life cycles of products, of non-saturated markets and EEE with a long life cycle. Nevertheless, it also envisages controlling improper treatment and illegal export. Moreover, target's stringency increases over time under the assumption that MS will organise and improve their waste management structures. Table 9 specifies the targets for the ICT category.

[8] From August 2018, the WEEE categories were revised, narrowing the categories from 10 to 6. However, for the purposed of this study, the previous categorization will be considered.

Table 7: Collecting target established by the 2012 WEEE Directive Recast

Period	Collection Target
From 2007 until 2015	4 kilograms on average per inhabitant per year of WEEE from private households
From 2016	45% calculated based on the total weight of WEEE collected, expressed as a percentage of the average weight of EEE placed on the market in the three preceding years in that Member State
From 2019	65 % of the average weight of EEE placed on the market in the three preceding years OR 85% of WEEE generated on the territory of that Member State

Table 8: Recycling and recover targets[9] per product category established by the 2012 WEEE Directive Recast (Annex V)

	13 August 2012 until 14 August 2015		15 August 2015 until 14 August 2018		from 15 August 2018	
Category	**Recycle**	**Recover**	**Recycle**	**Recover**	**Recycle**	**Recover**
1	75%	80%	80%	85%	80%	85%
2	50%	70%	55%	75%	70%	80%
3	65%	75%	70%	80%	80%	80%
4	65%	75%	70%	80%	80%	85%
5	50%	70%	55%	75%	55%	75%
6	50%	70%	55%	75%	55%	75%
7	50%	70%	55%	75%		
8	50%	70%	55%	75%		
9	50%	70%	55%	75%		
10	75%	80%	80%	85%		

Table 9: Recycling and energy recover targets for ICT, WEEE group 3

Period	Recycle	Recover
13 August 2012 until 14 August 2015	65%	75%
15 August 2015 until 14 August 2018	70%	80%
From 15 August 2018	80%	80%

The relevant point is that, although WEEE Direct requires registration of collected, reused, recycled and recovered WEEE, only the two last actions are effectively monitored by targets achievement. Therefore, there is a detachment between the concrete demands requested and discourse of encouraging options that deliver the best environmental outcome and promote the reuse of products. Considering that recycling corresponds to reprocessing waste materials for its original purpose or other purposes (see Table 4) and that recovery is the sum of recycling

[9] The achievement of the targets shall be calculated, for each category, by dividing the weight of the WEEE that enters after the recovery or recycling/preparing for reuse facility by the weight of all separately collected WEEE for each category (2012 WEEE Directive Recast, Article 11 (2))

process plus energy recovery, the legislation does not apply an effort to maintain the products closer to its original function.

5.2 The WEEE Regime at the Dutch level

Despite the establishment of Waste Directives by the EU, MS have the autonomy to establish their national regulations. As this study aims to analyse the Dutch WEEE System, it is necessary to understand how the Netherlands adopted and translated the EU WEEE Directive(s), to subsequently evaluate how the Dutch policy operationalizes the Dutch WEEE System.

5.2.1 The Dutch WEEE policy (1998 – 2014)

Discussions about establishing an adequate waste disposal infrastructure happen since 1992, in the Netherlands. However, only in 1998 was a Decree on removing white and brown goods (Minister of Housing Spatial Planning and the Environment, 1998) was established. Since then, the Decree already considered the EPR concept and the incentives for materials reuse. *"The general objective of the Decree is to establish a leak-free removal structure for white and brown goods: as much product and material reuse as possible and removal of the waste materials in such a way that the associated environmental health risks are limited (...) in such a way that prevention (eco-design) and reuse are stimulated, and disposal takes place in a cost-effective manner."*[10]

The Decree also presented several concepts implemented in future legislations, like compliance options through individual or collective systems for producers and importers and responsibilities for municipalities to provide collection structures. The necessity to monitor the disposal system by developing an adequate registration and control system by focusing on the number of discarded equipment, differentiation of collected equipment by category and tons of reused material were also considered. The Decree also contemplated a ban of waste dumping and prohibited incineration, *"the reason for these prohibitions is that all leaks in the cycle must be closed as much as possible, making recycling the only way."*[11] However, waste as an energy resource was an allowed practice, lastly, despite promoting enforcement control and establishing fines for the no fulfilment of obligations by producers, importers and suppliers[12], the Decree did not set any target to be achieved regarding recyclability or material recovery.

[10] Explanatory notes, goal
[11] Explanatory notes, 6. Ban on dumping and prohibition of incineration
[12] Explanatory notes, 12. Enforcement

Regarding the request of a system establishment, the Decree introduced guidance actions that should be taken, highlighting the central actors and implementing a scheme that could manage the collection and processing of white and brown goods. The establishment of a removal and processing structure was on 1 January 1999 and 1 January 2020, respectively[13]. To comply with the Decree requirements, NVMP was created in 1999 (see section 2.3) as the representative association for producers and importers, being an interlocutor of all parties involved in collecting and recycling of e-waste. The association actively seeks cooperation to improve the system, processes and results.

In 2004, the Netherlands presented the decree Management of Electrical and Electronic Equipment (State Secretary for Housing Spatial Planning and the Environment, 2004) containing rules regarding waste management and certain hazardous substances in EEE. The Decree strictly considered the EU WEEE Directive, contemplating the EPR concept.

In 2014 the State Secretary of Infrastructure and Environment (2013) updated the legislation according to the EU WEEE Directive Recast. As presented in the WEEE Directive Recast, the Dutch legislation review also contemplated an extension of the scope to all WEEE, extended and clarified producers and collective schemes obligations and responsibilities and defined higher collection targets. The WEEE Directive(s) established to the MS the requirement to present appropriate channels to ensure targeting monitoring. To monitor the demands compliance, the 2014 reviewed Dutch regulation explicitly pointed that *"The Stichting Nationaal (W)EEE Register established at Zoetermeer is responsible for drawing up and managing a register*"[14]. Therefore, the Nationaal (W)EEE Register (NWR) was delegated by the Dutch Government to organise the tasks related to the registration and reporting of EEE producers and WEEE treatment operators, following the same targets and requirements demanded by the EU WEEE Directive Recast.

In 2019, the foundation Stichting OPEN (Organisation of Producer Responsibility for E-waste Netherlands) was created. The organisation intends to strengthen the already in place Dutch WEEE System. The Dutch System needs to achieve the European collection target of 65% of all newly marketed equipment and recycle it in a high-quality manner (Organization of Producer Responsibility for E-waste Netherlands, 2019). The current collection and recycling system in the Netherlands is still fragmented, with several partners' involvement. To establish a more efficient process, the foundation will take responsibility for these actors and serve as a

[13] Explanatory notes, 2. General content of the decision, Entry into force
[14] Article 18

liaison partner within the government. The single organisational entity will coordinate contracts and also has the intention to promote more transparent operations, develop competition and promote cost efficiency.

Table 10 presents an overview of the decrees established by the Netherlands to comply with the EU WEEE Directive(s) and the organisations created to fulfil the demands presented by the legislations.

Table 10: Timeline of Dutch decrees related to WEEE and organisations founded to comply with directives related to waste and specifically for WEEE implemented by the EU

Year	Document / Organizations	Main topics
1998	Decree on the removal of white and brown goods	Establish a leak-free removal structure with as much product and material reuse as possible and removal of the waste materials associated with environmental health risks.
1999	NVMP Association	Representative association for EEE producers and importers.
2004	Decree Management of Electrical and Electronic Equipment	Dutch decree for EEE management based on the EU WEEE Directive 2002/96/EC.
2014	Regulation on waste electrical and electronic equipment	Establishment of new rules based on the EU WEEE Directive Recast 2012/19/EU
2014	Nationaal (W)EEE Register	Organization established by the Dutch Government to organize the tasks related to the registration and reporting of EEE producers and WEEE treatment operators
2019	Stichting Open	The OPEN Foundation focuses on achieving the statutory collection targets on behalf of all producers in an effective and efficient manner

5.2.2 The Dutch WEEE System at an operational level

The WEEE Directive(s) and the Dutch policies offered the necessary regulations to create the Dutch WEEE System. Overall, the process of adequately managing WEEE became cooperation between producers, sellers, municipalities and government that have different roles in the structure. Section 5.2.2 presents the Dutch WEEE System operationalization according to the legislative definitions and demands.

The EEE life cycle passes through several processes, as described next and represented in Figure 8. First, EEE enters into the market through producers and importers. Different configurations of producers are set, following the definitions presented by the WEEE Directive

Recast[15]. The selling channel used by producers and importers occurs through distributors. The Directive Recast does not define the type of distributors involved on the scheme, only highlighting two factors: 1) irrespective of the selling technique, including distance and electronic selling, those should be enforced in the same way; and 2) distributor means any natural or legal person in the supply chain.

The next step on the EEE chain is the consumers' equipment use. The Directive Recast defines consumers[16] in two sets 1) private households; 2) other than private households (hereafter: professional organisations or B2B), being commercial, industrial, institutional and other sources. The destination of the products after the selling is difficult to track, like the timeframe the products will become waste, shifting from EEE to WEEE. Several factors impact it, like product quality, repair possibility, technologies trends when mostly considering private households' cases. When dealing with professional organisations, the definition of a product as waste can consider factors like leasing contracts and equipment efficiency.

The MS needs to ensure that WEEE collection conditions are in place. Municipalities are responsible for making available free mechanisms (separated waste bins or collecting points) to separately collect the WEEE (municipal environmental street). Producers also have the responsibility for the WEEE collection, being responsible for the collection from the municipal environmental street. Moreover, distributors are also responsible for ensuring a free of charge return of such waste. Retail shops (presenting individual specifications) also need to provide free of charge collection to end-users who have no obligation to buy an EEE equivalent type.

Considering the responsibility that producers have over the product during its entire life cycle, they can set up and operate individual or collective take-back systems for WEEE. In the Netherlands, the stakeholder that comply via the collective system can choose between five collective schemes (National WEEE Register, 2020), that are in charge of operating collecting actions and WEEE processing. The producer pays the collective system as a representative, showing responsibility fulfilment. The collective operator is in charge of promoting WEEE tack-back and register at the NWR on the producer's behalf. Wecycle is one of the central Dutch collective systems and held the take-back system's monopoly until 2014, in the Netherlands. Besides, they are NVMP operational representative (see section 2.4).

[15] Article 3, definition *f*
[16] Article 3, definition *h*

After collection, WEEE pass by sorting and processing stages. Different processors sort the WEEE according to different categories. Processors can be coordinated by collection systems or have direct connections with individual producers. Moreover, as Figure 8 presents, despite most of the WEEE processing occurs inside the Netherlands, it can also occur in other locations. In the last stage, materials can re-entry in the market, through a recovery process, mainly in the form of recycling or energy recovery. According to the Dutch WEEE Flow Report (Huisman et al., 2012), the recycling process mainly happens through material recover by shredding. After, materials are sorted and separately sold like metal, plastic and glass to the industry as raw materials.

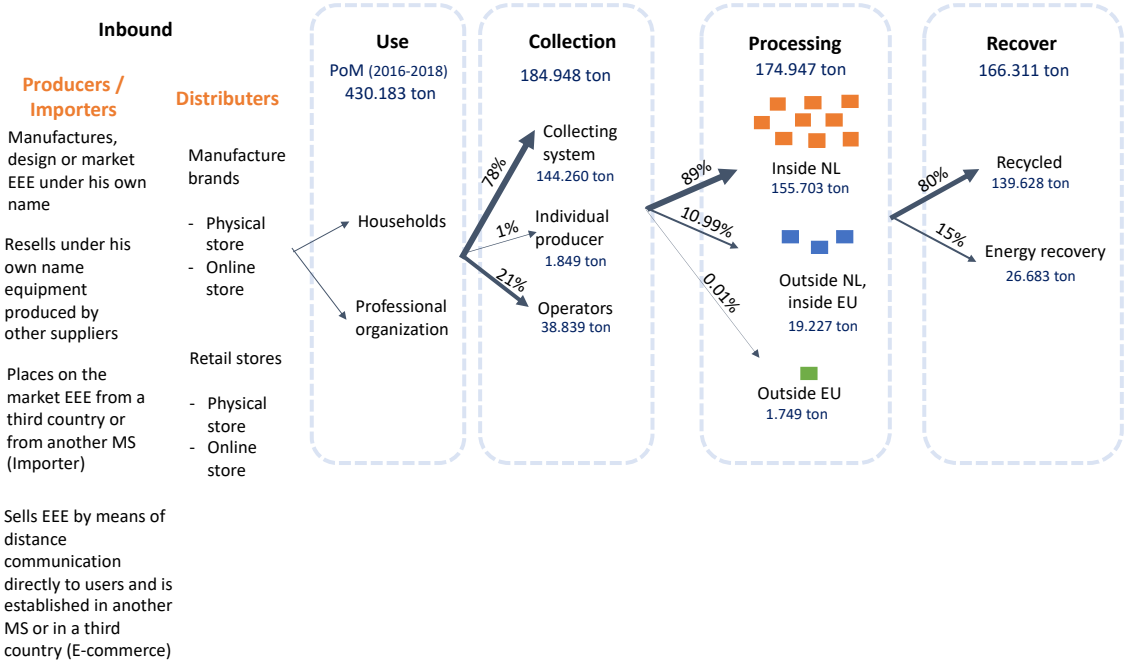

Figure 8: WEEE Dutch System scheme based on WEEE Directive Recast definitions and the Dutch National Register 2018 figures (National WEEE Register, 2019)

Besides presenting the Dutch WEEE System flow, Figure 8 also shows the amount of materials treated by the system in 2018. It is possible to realize that not all products put on the market return for proper EoL management. From the total amount collected, 78% is through the collecting system. 89% of the material processing happens inside the Netherland. 95% of all the processed material is recovered by recycling (80%) or energy recovery (15%). The 5% remaining is destinated to incineration, according to NWR[17].

[17] NWR interview

Moreover, Figure 8 presented the main stakeholders considered by the Dutch WEEE System and the stakeholder that need to report obligations to the NWR. However, the scheme does not explicitly include many actors. The collective systems control most of the operational part of the WEEE treatment (Figure 8), and they establish partnerships with several stakeholders related to more specific parts of the process. Many other actors are also part of the Dutch WEEE System but have lower representativeness.

Figure 9 presents the main collecting streams in which Wecycle operates to display actors that are also involved in the Dutch WEEE System. Despite the WEEE Dutch System have four other collecting systems registered at NWR, Wecycle corresponds to one of the central systems.

The mapping of this specific scheme is worth closer to analyse the stakeholder involved in the Dutch WEEE System. By first examining the overall system based on policies' demands, it is impossible to outline all the stakeholders involved in daily operational processes that can often be overlooked and have their claims and obligations not considered.

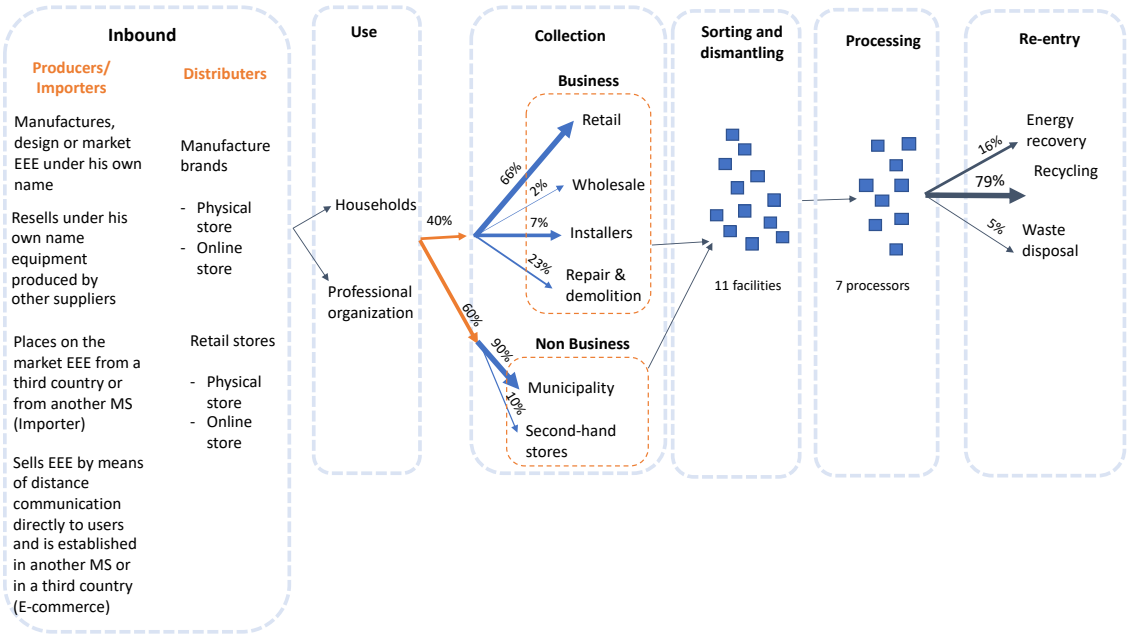

Figure 9: Wecycle collecting stream (2018 figures). WEEE stream chain with the volume flow based on the percentual material collected by Wecycle (Wecycle, 2019)

According to Wecycle 2018 report (Wecycle, 2019), the WEEE collection corresponded to 105.500 tons in collaboration with 285 Dutch municipalities and 70 second-hand stores, corresponding the 60% of all collected volume. The remaining 40% collection occurred in partnership with business organisations. After collection, the WEEE is sorted, dismantled and

processed by partners' facilities. In total, 95% of the collected material re-enter the market through recovery processes.

5.2.3 The effectiveness of the Dutch WEEE System

Table 11 and Figure 10 present an overview of the WEEE amount put on the market, collected, recovered and recycled. The results provided by Eurostat and NWR consider the data available between the years 2005 and 2018. The amount of material collected, recovered and recycled has approximately doubled between the analysed years. However, it is still significantly below the PoM amount, which has been sharply growing.

Table 11: WEEE results overview with amounts presented in tonne (Eurostat, 2020; National WEEE Register, 2019) *18*

	WEEE Results Overview													
Tonne	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
PoM								324,717	306,011	319,941	342,762	371,592	417,362	500,428
Collected	89,827	94,484	98,190	103,319	108,457	128,119	132,197	123,684	117,499	141,805	145,192	154,675	166,189	184,947
Recovered	77,696	82,787	88,356	93,822	97,385	121,084	123,620	118,036	112,281	137,013	139,034	148,219	159,551	166,311
% Recovery	86%	88%	90%	91%	90%	95%	94%	95%	96%	97%	96%	96%	96%	90%
Recycled	67,899	73,475	77,617	83,756	85,515	102,325	108,102	102,614	97,669	116,841	119,154	125,065	139,352	139,628
% Recycled	76%	78%	79%	81%	79%	80%	82%	83%	83%	82%	82%	81%	84%	75%

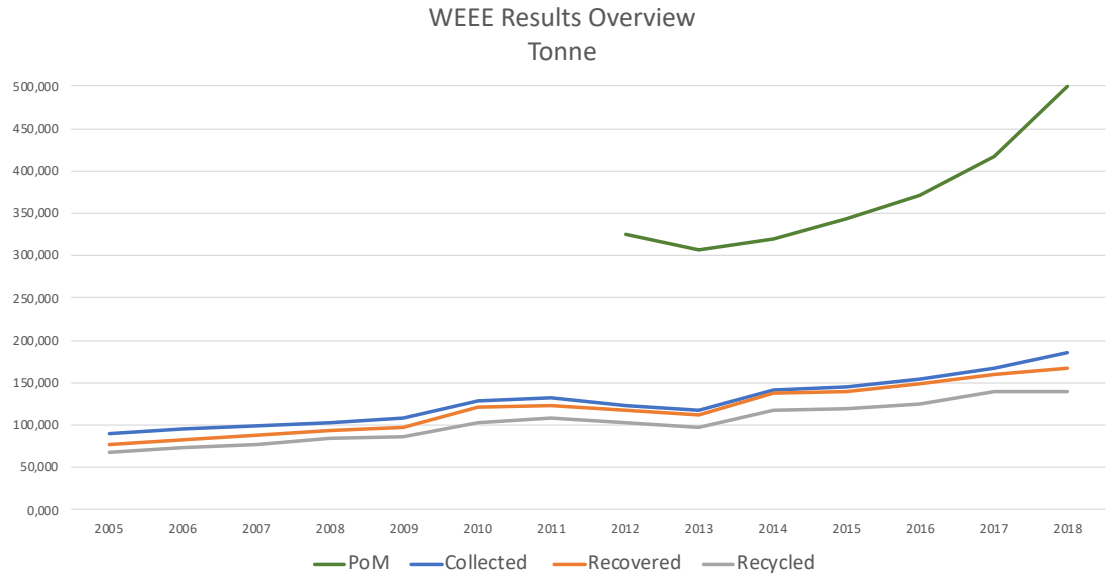

Figure 10: Evolution of the WEEE treatment considering the 2005-2018 figures (Eurostat, 2020; National WEEE Register, 2019) 19

[18] The 2018 data was retrieved from the NWR report. Eurostat only has information available until 2017.
[19] The 2018 data was retrieved from the NWR report. Eurostat only has information available until 2017.

5.2.3.1 Collecting targets

As previously presented, the WEEE Directive establishes the fulfilment of 3 different targets, WEEE collecting, recycling and recovery (recycling plus energy recovery). Table 7 presents the collecting targets divided into three phases. Figure 11 presents the results from the first phase (2005-2015). Until 2015, the target based on the average amount (kg) collected per inhabitant (from private households) per year. For all measured year, the Netherlands reached the target by presenting higher achievements than the EU.

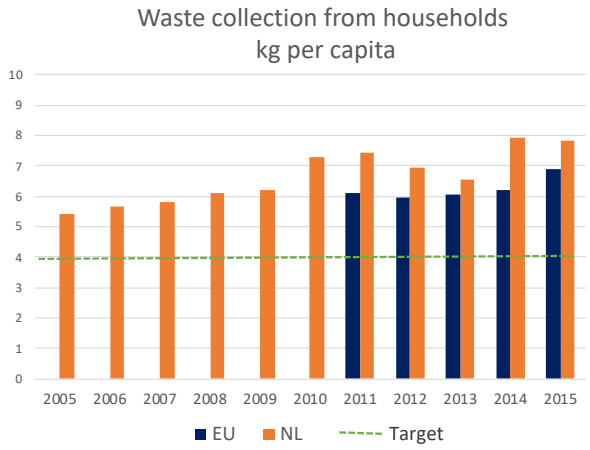

Figure 11: Dutch WEEE collecting achievements until 2015, considering the total WEEE collected from households from the Netherlands and EU, and the 2012 WEEE Directive established target for the first period[20] (Eurostat, 2020)

Figure 12 shows the collecting achievements for the years 2016 to 2018. As explained in section 5.1.2, from 2016, the collecting methodology uses the three previous year's average collection for the PoM calculation. For the years of 2016 until 2018 (second phase), the proposed target was 45% of WEEE collected based on PoM. From 2019 (third phase), the target raised to 65%. For all the years correspondent to the second phase, the Netherlands could achieve the goals. However, even with the 2019 collecting results not available yet, it is highly probable that the target will not be achieved, due to the last years' achievements trends.

The ICT category presents the percentual waste collected of 52%, 51% and 60% for 2016, 2017 and 2018, respectively. The achievements are sufficient to comply with the second phase targets (45%) but not enough to achieve the third phase target proposal (65%), as shown in Figure 13.

[20] The numbers referring to the EU are not available for all the years at the Eurostat database

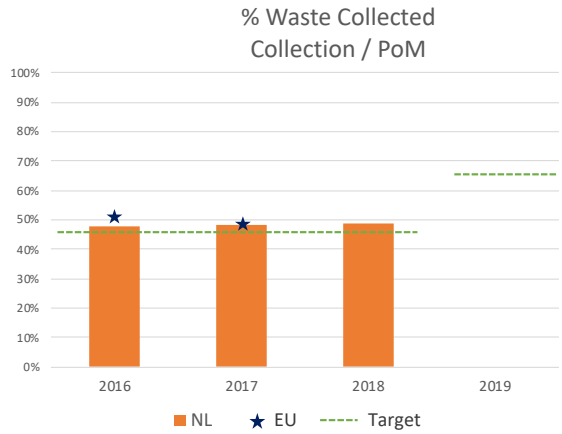

Figure 12: Dutch WEEE collecting achievements (2016-2018), considering the WEEE collected from the EU. The established targets correspond to the second (2016-2018) and third period (from 2019) (Eurostat, 2020; National WEEE Register, 2019)[21]

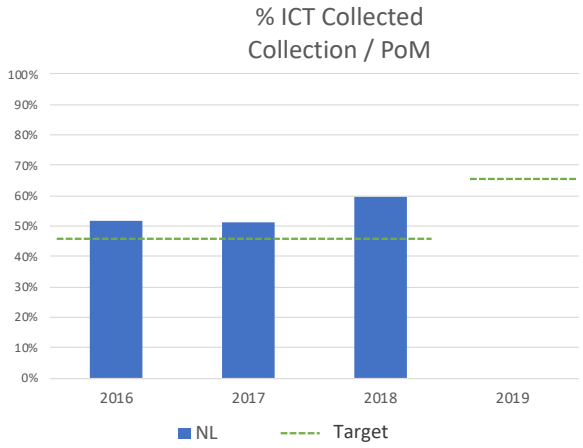

Figure 13: Dutch WEEE collecting achievements (2016-2018), for the ICT category. The established targets correspond to the second (2016-2018) and third period (from 2019) (Eurostat, 2020; National WEEE Register, 2019)[22]

5.2.3.2 Recycling and recovering targets

Table 12 shows that the recycle and recover attainments are already higher than the stipulated targets (see Table 9). As previously explained, the WEEE Direct recognises the term recovery as recycling and energy recovery activities.

[21] The 2018 data was retrieved from the NWR report. Eurostat only has information available until 2017.
[22] The 2018 data was retrieved from the NWR report. Eurostat only has information available until 2017.

Table 12: Dutch WEEE recycling and recovery achievements (Eurostat, 2020)[23]

		Recycle									
Category	WEEE	2012	2013	2014	Target	2015	2016	2017	Target	2018	Target
1	Large appliances	83%	85%	84%	75%	84%	83%	85%	80%		80%
2	Small household appliances	78%	80%	78%	50%	78%	77%	80%	55%		70%
3	IT and telecom equipment	85%	83%	79%	65%	80%	79%	83%	70%		80%
4	Consumer equipment	86%	86%	84%	65%	82%	80%	84%	70%		80%
5	Lighting equipment	86%	86%	84%	50%	80%	82%	85%	55%		55%
6	Electrical and electronic tools	78%	80%	78%	50%	76%	75%	79%	55%		55%
7	Toys, leisure and sports equipment	78%	80%	76%	50%	76%	73%	78%	55%		
8	Medical equipment	85%	83%	76%	50%	75%	72%	78%	55%		
9	Monitoring and control instruments	76%	80%	75%	50%	78%	78%	83%	55%		
10	Automatic dispensers	57%	30%	88%	75%	85%	88%	90%	80%		
	TOTAL	**83%**	**83%**	**82%**		**82%**	**81%**	**84%**			
		Recover									
		2012	**2013**	**2014**	**Target**	**2015**	**2016**	**2017**	**Target**	**2018**	**Target**
1	Large appliances	95%	97%	97%	80%	96%	96%	97%	85%		85%
2	Small household appliances	96%	97%	96%	70%	96%	95%	93%	75%		80%
3	IT and telecom equipment	97%	97%	95%	75%	95%	95%	96%	80%		80%
4	Consumer equipment	98%	97%	97%	75%	96%	97%	96%	80%		85%
5	Lighting equipment	95%	97%	97%	70%	96%	96%	95%	75%		75%
6	Electrical and electronic tools	97%	97%	97%	70%	96%	96%	95%	75%		75%
7	Toys, leisure and sports equipment	97%	97%	95%	70%	96%	94%	93%	75%		
8	Medical equipment	98%	99%	96%	70%	93%	96%	95%	75%		
9	Monitoring and control instruments	88%	98%	97%	70%	91%	94%	91%	75%		
10	Automatic dispensers	62%	34%	98%	80%	96%	97%	99%	85%		
	TOTAL	**95%**	**96%**	**97%**		**96%**	**96%**	**96%**			

Figure 14 focuses on the ICT category, showing that recycling and recovery for ICT are higher than the stipulated target. However, the fluctuations in the recycling achievements over the last years indicate that the target from 2018 onwards might not be achieved.

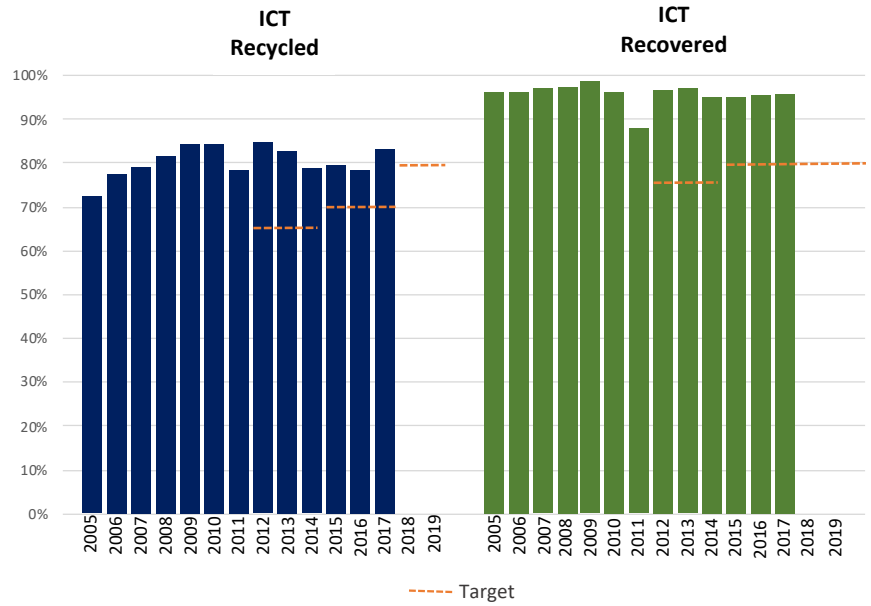

Figure 14: Dutch recycling and recovery achievements for the ICT category, considering the 2012 WEEE Directive established target (Eurostat, 2020)[24]

[23] Eurostat only has information available until 2017.
[24] Eurostat only has information available until 2017.

5.3 The Dutch WEEE System: Stakeholder's perspectives

After analysing the policies that guide the system and mapping the main actors involved, it is necessary to consider how the stakeholders understand their role in the system. Stakeholders also indicated the policies' demands that are not fully translated into the system and how to promote CE principles into the process.

As presented in section 4.1.2, interviews were held with stakeholders that play in different sectors of the system. NVMP has the benefit of having a broad knowledge over the structure, communicating with the government, producers and processors. While NVMP is responsible for setting a structure that allows the achievement of expected targets, NWR can measure the system's effectiveness and manage all the required information provided by the stakeholders. The other interviewed stakeholders correspond to the system's operational parts, which are collection, sorting, and processing.

The interview analysis comprises different topics, considered as most relevant for this research. Moreover, although the research focuses on ICT equipment, the interviews compromised in understanding the entire WEEE System and its different categories, since the system does not apply different rules for each WEEE category.

5.3.1 Compliance of the targets by the Dutch WEEE System

The WEEE System's primary goal is to achieve the collecting and recovery targets established by the WEEE Directive. However, as Figure 12 shows, the biggest challenge is to increase the WEEE collection rate to achieve the 2019 goals. Hence, the current challenge is to track and collect the missing volume. Matters like the incorrect WEEE disposal and exportation are possible problems the system needs to resolve. Wecycle pointed, "*We know that there are exports to other countries, but we do not know what companies are involved in. We also know that consumers discard e-waste through the waste bin. There are several ways to discard e-waste. The difficulty is to convince consumers and companies to discard e-waste in the correct channel. Then, it is a rather closed system".* Wecycle, based on their studies, estimates that around 30,000 tons[25], per year, of WEEE, is incorrectly disposed on household bins.

5.3.2 Responsibility for correct WEEE disposal

Two paths differentiate the EEE consumption, household and professional use (see Figure 8 and Figure 9), generating different disposal streams. Producers have a closer relationship with

[25] of information are provided during the Wecycle interview

consumers of EEE destined to professional use. The direct interaction between producer and consumer allows the producer to manage the product's EoL. On the other hand, the interaction between producers and household consumers is not direct. Retailers usually intermediate the selling process, while collective systems manage the product's EoL.

Regarding households' consumers, producers heavily rely on Wecycle on the promotion of consumer awareness campaigns, acknowledging them as responsible for communication. "*Most communication happens just through the compliance scheme. Wecycle needs to communicate, and they need to promote knowledge about WEEE correct disposal towards all consumers. Moreover, all products need to be properly disposed at the municipalities or in the stores"*[26]. Therefore, most communication regarding proper disposal or any other initiative regarding WEEE occurs through the compliance scheme. Producers acknowledge the efficiency of the collective solution and highlight that having one stakeholder responsible for communication allows a more precise message. Otherwise, different producers would have individual communication schemes, and consumers would suffer to comply with the various requests correctly. Producers present some individual actions, though highlighting the presence of disposal information in their user's manual and place the wheelie bin symbol in their products is legally mandatory. Therefore, producers do not take any independent or innovative action regarding this topic.

The regulation requires awareness promotion, and Wecycle complies with it by promoting regular customer's campaigns. However, the budget destinated to the campaigns was not disclosed. Also, partnerships are established with municipalities to increase communication channels and awareness promotion. *"We have public campaigns every year to help consumers to tackle this problem. We have communication channels with municipalities, to convince them to help us."*[27]

The promotion of correct WEEE disposal by household consumers is a fundamental factor to all stakeholders. Although NVMP, through Wecycle operations, promotes a structure that ensures the availability of collection points in diverse locations (see Figure 9), the decision to apply correct product disposal is still a consumer responsibility. Moreover, if the EEE still has value, or it has repairment possibility, the assumption is that consumers will take measures to prolong the product lifespan. *"The disposer intention is established by law. If used EEE still*

[26] Philips interview
[27] Wecycle interview

has value, the assumption is that the consumer will sell it or give it away. Once it has become WEEE, the consumer can choose to dispose of the equipment correctly."[28]

Despite provide mechanisms (informative material about correct WEEE disposal and WEEE collection points through the municipalities and in business locations) to promote WEEE proper disposal, NVMP highlights that consumers have to actively contribute with the collection success, as established at the WEEE Directive. Even though the legislation does not allow WEEE disposal on regular bins, the legislative measure does not have much impact on the consumers' behaviour. No fee penalty is applied to consumers who incorrectly dispose of WEEE, making it difficult to track the consumers' compliance with the law. Plus, many equipment are also kept at people's households even when not used anymore, reducing collected and treated material. Wecycle highlights that the difficulty in promoting correct product disposal happens for WEEE and other waste streams as paper and clothes.

For products destinated to professional use, considering a business to business (B2B) environment, the producer controls the product's EoL management. On the B2B market, producers have a closer connection with the business partners than the general consumers, facilitating communication and the logistic process. *"Regarding B2B products, we try to reach every customer to keep as much control over the products. So, we like to get all products back by ourselves. We try to collect as much as possible, to keep that in a closed-loop. For consumer products, we rely on the collective system to do the most of the work."*[29] For B2B transactions, producers take responsibility for WEEE collection, maintaining a close loop of the EoL management. The direct connection promoted by the B2B environment facilitates decision making regarding the product destination, not having Wecycle as an intermediator.

5.3.3 Integrating repair and refurbish stakeholders on the Dutch WEEE System

Stakeholders recognise the importance of repair and refurbish shops in the system. "*The cooperation between Wecycle and thrift shops creates a win-win situation, contributing to the circular economy. 40 to 50% of everything that arrives at a thrift store is resold, the rest is handed over to Wecycle for recycling. Electrical appliances that can no longer be repaired by the repair cafés are also handed to Wecycle. Wecycle keeps consumers informed about the partnerships through their operational disclosure campaigns."*[30] Although this type of

[28] NVMP interview
[29] Philips interview
[30] NVMP interview

transition is measured and made available for the general public by Wecycle, such actions are not officially reported to NWR.

For producers, the engagement with recycling and refurbishing stores is more complicated. Producers highlight two main concerns over the electronic products having any kind of intervention, quality and safety maintenance. *"In Europe, we have a huge network of authorised repair centres. I emphasize authorised because there is a lot of discussions about it in Europe. Parliament wants to give the right to repair and make available repair manuals and tools for everybody. However, we do not like this, generally as an industry, because brand liability issues can occur. Or even worse, something safety or fire-related. We want to keep our cooperation with the people we know, and we train to assure that it is fit for purpose."*[31]

Producers claim the necessity to maintain control over the repair and refurbish shops, promoting regulations and adequate training. The implementation of such requirements, the promotion of partnerships with authorised repair centres, is self-established by the producers. In such cases, producers promote training with experts, provide adequate machinery and necessary spare parts for repairment and ensure security and quality measures to be followed. Also, the close relationship between the actors brings as a benefit for producers the capacity to have fast feedback about their new products, regarding recurrent fail or other technicality that needs improvement.

Processors agree that repair shops should have a higher representation of the WEEE system by receiving incentives but also complying with regulations. *"Absolutely, but these organisations need to grow in professionalism. Furthermore, it is important to develop a good business model."*

5.3.4 Promotion of reusing, repairing and refurbishing activities over recycling and energy recovery

The interviewed organisations recognise the importance of promoting initiatives that guarantee products' higher value retention. However, as previously emphasised, they still underline the consumer's responsibility for such matters.

Even recognizing consumers as the primary stakeholder to promote alternative circular actions, other stakeholders also have a role in the promotion of WEEE higher value retention. Wecycle hosts webpages like *watismijnapparaatwaard.nl* (what is my device worth). The website does not precisely inform about customer's EEE value but helps them to decide about possible

[31] Sony interview

destinations to their products. The website provides information about repair or resell options, that promote longer life to the products, and about locations to correctly dispose of the WEEE. *"That website offers a different path through discards of electronic equipment, but that still has a value for other customers."*[32]

The interviewed processor holds a refurbishing company aside from the processing facility (mainly for ICT products), recognizing the importance of giving priority to circular approaches that preserve the product's initial functionality. "*The first step is to reuse. For instance, a laptop can often be repaired with a new battery or a better hard disk."*

Moreover, according to the processor, many products are not worth to be repaired or refurbished, resulting in quality decreasing. *''This is partly due to the sharp increase in imports of products from China, which have low quality and a very short lifespan*." When giving priority to actions that promote products, value retention, quality, and applicable repairment must be considered.

Producers underline that different EEE types should prioritize different value retention actions. Products with low aggregated value usually have low reselling and repairing options. By taking into consideration quality assurance, logistic and economic perspectives, recycling is advised as the most effective action. "*If you have a product that's worth less than a hundred euros, then that is usually a cut-off measure. That kind of product is not repaired, just scraped."*[33] Products with high-end technology that have specific features (waterproof devices, per example) should be designed to have a long durability, not focusing on modularity parts, for instance, that can facilitate the equipment repairing or refurbishing. "*If we are developing a big medical device, probably refurbishment is the key criterion. We make sure that refurbishment is possible. If we are looking at a vacuum cleaner, we make sure that people can easily repair it. The wheels in a vacuum cleaner break quite often. So, we assure you that the wheels are very simple to replace, then people can keep using the machine for much longer. If we look at an electric toothbrush, probably the most important thing is to make sure it just lasts for a long period. Because it is all watertight and completely sealed, you do not want to open it. Durability is the most critical consideration. Therefore, we are going to look at the entire product portfolio to determine the key circularity drivers."*[34]

[32] Wecycle interview
[33] Sony interview
[34] Philips interview

5.3.5 Complexities in attending the requirements related to product design

Legislation requires that product development presents an eco-design approach. The EU already presents material efficiency standards. The Circular Economy package tackles points as recycled materials contents, reusability and recyclability. However, producers agree that it is not possible to design products that follow the most diverse sustainable requirements.

Products that follow all standards might not be effective since a design that focuses on durability can hinder the recycling process. Considering the long list of compliance requirements, producers set priorities on attending specific considerations depending on the EEE functionality. *"We have largely discussed it. We try to make the policymakers aware that one product cannot do everything. The Commission pushed in 2015 in the first Circle Economy Package the material efficiency standards that concerned recycled material contents, reusability and recyclability. The industry is working on it. It is logical that one product cannot be 100% perfect in everything. Considering durability versus recyclability, producers might make a sort of a Russian tank that just lasts 400 years. But from a recycling perspective, it would be impossible to process the material. So, we need to focus on key aspects."*[35] Producers highlight that for different products portfolio, design for circularity should consider different key aspects. "*We are expanding into a design for circularity, not just designed for recycling. And then, circularity can be either reuse, refurbishment, parts harvesting. For different products designed for circularity will mean different things."*[36]

Moreover, producers are still focusing on features that are under a long-term discussion, as energy use. Chemicals are also a concern, but many were already phased-out or are already presenting correctly handling during EoL management. *"Still, the most important concern, from an environmental perspective, is energy use. That is still the biggest impact. So, we focus on energy reduction in the use phase, but also the charging and standby modes. And then, on the chemical phase-out, by making sure that we do not use hazardous chemicals."* [37] *"There are new energy efficiency requirements that are coming into force, considering extremely rough energy-saving requirements."* [38]

The use of recycled or mixed plastic is also a concern since processors highlight the difficulty of promoting the correct process for these materials. From the materials usage perspective, an

[35] Sony interview
[36] Philips interview
[37] Philips interview
[38] Sony interview

interesting point is the already established use of recycled metals on production. For plastics, however, there is still a necessity to make specific demands for the use of recycled material. The use of virgin plastic on the production line is the default since material availability and price are still an incentive. "*We focus a lot on using more recycled plastics. For metals like copper or aluminum, it all gets pretty much recycled. So, in the use of any steel or copper, always an amount of recycled material is present. It is not necessary to ask for it. With plastic, if not requested, the delivery is always based in 100% virgin plastics. It is necessary to demand recycled plastics, specifically."*[39]

Additionally, the use of recycled materials might induce consumers to think the product quality has decreased, even though the consciousness about recyclability is increasing. "*It is a delicate balance because if you use 100% recycled plastic, the product might look a bit different than the customer expected. There is also a consumer mindset. People might think, or that is how it used to be at least if the product has recycled material, the product's quality is lower and will not last too long. Moreover, of course, there is the cost related, treating and reusing plastic is very expensive."*[40]

From the processor perspective, their concern about product design is based on criteria as value for reuse, risks in processing and recycling cost. Concerns about health and safety are also present, especially connected with the use of risk substances and batteries. The interviewed processor highlighted an increase in product design that facilitated equipment dismantling, allowing higher rates of recyclability. However, in recent years, the processor perception about new products presenting design concerns related to recyclability and disassembly has levelled off. "*From 2010 to 2017, there was an increase, but in recent years it has levelled off. Recycling or reuse is hardly taken into account in the design process."*

Furthermore, Europe has an operational framework that can address another challenge in product design. In Japan, Sony has direct responsibility for the recycling plants. This condition can favour innovation and more accurate knowledge about the product EoL status. Processors have direct contact with designers to discuss the requirements that lead to changes like a better recycling process or reduced material use. Another difference between Japan and Europe is that product processing is made by manual disassembly while in Europe, most of it is done by a mechanical process. *"In Japan, everything is done by manual disassembly. There is a focus on having the sort of maximum yield of resources. That is an example where Sony is forced to,*

[39] Philips interview
[40] Sony interview

for our economic benefit, to do excellent product design."[41] In such cases, the benefit of manual management is the promotion of higher material recovery and also a better understanding of the changes product design should have to increase durability or facilitate recyclability.

5.3.6 The WEEE's value return

The stakeholders' disposition in supporting the reduction of the WEEE amount by incentivizing reuse, repair and refurbishing also emphasise a business model problem. Processors financially rely on WEEE processing and recycling, retaining value over the recovered materials or energy return. Meanwhile, producers do not see a financial return on investing in product design that can lead to the adoption of higher circularity options.

The sorting and processing phases have as main goal to separate the products in parts that can be sold to specialized processors, depending on the WEEE category and materials composition. Most of the processor's profit comes from the sorting and dismantling work, plus plastic and metal trading. Processors acquire unprocessed WEEE from collecting organisations, as Wecycle, or individual producers and sell the processed material for recycling companies that are interested in iron, aluminum and printed circuit board, per example.

From the Wecycle and processor's perspectives, all the products will automatically be processed, considering recycling purposes. "*If we get it, it is usually for dismantling."*[42] At the sorting stage, products and materials are mainly separated into different processing streams, not considering further inspections to analyse the circular alternative application.

From the producer's perspective, despite the materials' importance and value, promote their return into the producer's ownership is logistically inefficient. Also, the promotion of an individual system focusing on material return is more expensive than the collective route compliance. "*The logistics, compared to the material value, is costly.*"[43] Therefore, processors have profiting advantages over producers regarding metals, plastic or any other material trading. This economic factor tends to make processors validate the recycling approach over other alternatives, even emphasizing metal processing companies as one of their most crucial stakeholder connections. Furthermore, NVMP and Wecycle are non-profit organisations financed by the producers under the EPR model. However, sorting facilities, processors, and recyclers must maintain their operations and profit from it.

[41] Sony interview
[42] Wecycle interview
[43] Philips interview

5.3.7 Customer's consumption patterns

Producers see customer's preference for new products as a difficult tendency to oppose. Technology had a fast development in the last 20 years, causing significant improvements. Hence, product development in transition periods can create an impact on quality, since products can have a significant change in a short period, accelerating the disposal factor. *"It is the demand of the consumers. We kept making TVs that no one wanted to buy anymore because there was not as cool as the flat ones. However, at the time, the quality of the new ones was not good enough."* [44]

Furthermore, the current technology business model requires constant investment and new product creation, incentivizing the consumer's consumption patterns. *" Sony is a for-profit company. Of course, we always want to launch a new model, want more demand and find new features that are better for the consumers. The consumers are also not rational. They might have a perfectly fine phone, but if iPhone 11 comes out, then that is the cool one, and they want it."*[45]

5.3.8 The Dutch WEEE System structure and the promotion of higher circularity approaches

NVMP recognises a transition on the system's behaviour, *"the focus will shift much more towards circularity and a closed-loop without waste*." However, the current WEEE System is not fully prepared to further address this transition.

In general, the interviewed stakeholders agree that targets should also concern other circularity actions, that currently are not satisfactorily measured. The transition into a desired circular economy requires specific definitions of circular principles and the establishment of targets. *"I think it has more to do with fine-tuning, then proposing new big legislation. It is more like how are you going to make sure that it is (the circularity principles) accountable? If I, for example, do an old equipment repair, does that count as circularity or not? And if you think it is circular, how is it possible to make sure that it has also taken care of in an administrative manner? Many circular projects are happening, but nobody actually knows what is the amount of circularity right now. There is not much data about this subject. If you do not have a target,*

[44] Sony interview
[45] Sony interview

and if you do not want to define what reuse is, then it is difficult to change the system, into depth, into the needed directions."[46]

Targets have the power to incentivize actions and recognise the already accomplished work, as promoted by several organisations as thrift shops, second-hand and refurbishing ICT stores. However, these stakeholders' work is not officially recognised by the WEEE System, according to NWR registers.

Producers recognise that in the future, more circularity requests will come from the MS*, "I guess the member states are waking up to the fact that reuse targets will be applied as we have with collection and recycling targets now. How can we optimise the systems also to meet those targets?"*[47]. Producers also recognise the development of a higher number of circular projects. The B2B interactions facilitate the introduction of business models based on leasing, for example. However, the implementation is still low.

For the processing actor, their interaction with the circularity concepts is still low. Despite the interviewee highlights that the next great challenge on promoting circularity is to produce more accessible to repair EEE, the processor does not see itself as a changing agent.

5.3.9 Stakeholder's overall considerations about the Dutch WEEE System

The interviewed organisations agree that, in general, the Dutch WEEE System conducts effective work, and the legislation in place addresses the main points necessary to run the system satisfactorily.

For Wecycle, the current legislation does not need to go through significant changes.

From the producers' side, the system is efficient and satisfactory. For them, most parts of the legislation are mature, although improvements are still necessary. The main complaint is the lack of a modulated recycling fee, applied according to the product's environmental performance. Products with the presence of recycled material in its composition and that present design initiative allowing easier repair and refurbishment should be contemplated with a lower fee. On the contrary, products that make use of chemicals and are difficult to dismantle, frustrating the recycling process, should pay a higher fee. Hereafter, producers believe that products should have more individual incentives. Furthermore, producers indicate the

[46] Wecycle interview
[47] Sony interview

existence of a significant interaction gap between the producers and recyclers, making it necessary to improve the system to integrate the value chain better.

NVMP recognises that improvements need to be made on the current Dutch WEEE System to address the WEEE demands efficiently. Despite the Netherlands already have a consolidated system for WEEE collection and treatment, the results achieved are still under the stipulated targets. The introduction of the new management body, Stichting OPEN (see Table 10), will focus on ensuring the effective and efficient achievement of legal objectives on behalf of all producers. In the new norms, producers will centrally control the target's performance, being able to hold discussions with the government on a joint basis about objectives achievements. The new approach responds to the wishes of the Ministry of Infrastructure and Water Management (IenW) to ensure that the targets are met as effectively as possible through improved management of the organisation and implementation of e-waste collection and recycling.

5.4 Analysis of the Dutch WEEE System

The analysis of the European and Dutch legislation and its translations into the Dutch WEEE System allowed the answering of the first sub research question proposed by this research: *How is the Dutch WEEE System currently organised?*

The goal of analysing the current structure of the Dutch WEEE System was to evaluate if the system was well structured to comply with the WEEE policy's demands and to measure the compliance level of the system with the CE principles. The analysis outcome is that the system still faces challenges on the achievement of the collecting target proposed by the WEEE Directives. Furthermore, the system's compliance with the CE principles is still based on the CE 2.0 view that focus on output measures and promotes results regarding longer loop value retention (recycling and energy recovery).

The existing Dutch WEEE System, aside from dedicated effort to improve waste collection to achieve demanded targets, needs to promote higher adoption of circularity principles. More attention must be devoted to understanding how to stimulate products resell, reuse and parts remanufacturing with a view that such actions can prolong the product life cycle.

The evaluative research recognised the necessity to focus on changes that can promote more effective legislation that better support the CE principles. Advance on the consideration of waste hierarchy principles will require the adoption of a set of definitions by the WEEE

legislation and changes on the system structure, with the inclusion of stakeholders that are, in many times, put aside from the decision-making process.

Four actions are proposed to support the enhancement of the circularity principles adoption by the WEEE System. First, by providing a clear definition of the circular actions. Second, officially recognise all the stakeholders present at the system, like repair cafes. Third, require information reporting from all stakeholders involved with any circular action. Fourth, establish targets for other circularity actions besides recycling and recovery.

5.4.1 Clear definitions of circular actions

Propose further CE principles adoption involves a clear concept's definition. The terms considered relevant in this research support the promotion of actions that conduct a product higher value retention, being prevention, reuse/re-use, resell, refurbish, recycle and recover. However, the Directives and legislation presented along the years are not entirely coordinated with the concepts' definition. Plus, some other concepts were suggested in the regulation text but not adequately described. Three central European and Dutch legislations provide specific information on WEEE management and take into consideration the CE concepts. The 1998 Dutch Decree on White and Brown Goods and the two WEEE EU Directives (from 2002 and 2012). The Dutch WEEE legislations of 2004 and 2014 (see Table 10) follow the instructions of the EU Directives.

The term prevention shows an evolution in its definition, considering the development of the waste management proposals. At the 1998 Decree, the term was first included without further presentation of the actions related to it, just pointing that prevention should be stimulated. After both Directives presented a more precise definition about the term, defining it as the reduction of waste production by extending the products life spam.

The term reuse/re-use has a more complex definition. The 1998 Dutch Decree presented the term including a broad scope, considering reuse as any operation that could consider reuse of entire product, some parts or as fuel use. This definition hinders the general orientation of prioritising actions that preserve, at most, the product original function. However, in 1998, there was still significant concern about landfills ban, per example. Therefore, any product or material reuse was a step towards better WEEE management. The later introduction of the WEEE Directive did not help on clarifying the diverse functions of the term reuse, simply defining it as the continued use of the equipment or components (see Table 4). However, considering circularity levels (see Table 1), the different activities connected with the term can

be placed on different levels (short and medium loops) and have diverse stakeholders involved. Moreover, the term typography changed from reuse to re-use from 2002 to the 2012 Directive. Although its meaning remained the same, this can cause some confusion on understanding the applied activities the term refers.

The term resell, with the meaning of giving a second life to a product, is not considered. However, the 1998 Dutch Decree recognises the existence of a second-hand circuit, thrift shops and domestic trades that give a second life to products.

The term refurbished is only mentioned on the Directives. However, a definition is not applied. The term is seen as a type of treatment the product can suffer to facilitate product reuse. The broad definition of the term reuse has, as a consequence, the lack of proper clarity to other terms that consist of longer loops and involve different stakeholders and business model, like B2B. The 2012 WEEE Direct includes the request of producers to provide information free of charge about reuse (including maintenance, upgrade, refurbishment and recycling) and treatment. However, this request generated disagreements from producers' side, as presented in section 5.3.3.

Recycle is connected with reprocessing activity in all legislations, but discards energy recovery operations. At the same time, recovery measures the entire process of reprocessing, considering recycling plus energy recovery. As Table 8 shows, recycle and recovery are the only targets requested to be achieved by legislation.

Provide a clear definition of terms allows to effectively identify the actions that can improve products value retention and measure the progress on the promotion of such actions. Moreover, promote a clear definition of the circular terms facilitates the mapping of actors involved in each part of the system. At the moment, activities that encourage closer loops and do not include materials entire reprocessing, as repairing and refurbishing, are still under the recycling scope.

5.4.2 Stakeholders inclusion on the Dutch WEEE System

Although the main stakeholders are included in the system, being registered and complying with legislation, several other stakeholders are overlooked. In this case, their demands are not considered, and compliance is not requested. The fact that WEEE management actions are not completely clear provokes a lack of complete products and materials flows mapping.

In the Dutch 1998 Decree, repair companies and small shops are part of the WEEE System. The goal's definition established on the Decree involved: *"the division of tasks and responsibilities between consumers, suppliers, repair companies, municipal authorities, producers and importers"*[48]. The acknowledgment of a second-hand circuit was also present in the 1998 Decree *"The manner in which white and brown goods are currently removed is fairly diffuse. Some of the discarded equipment finds its way into the second-hand circuit and (metal) recycling (old iron trade, shredder companies)."*[49]

As the policies evolved, the recognition of repair shops or second-hand circuits as actors with a decision-making role was lost. Moreover, the release of the EU WEEE Directive and its Recast did not help in clarifying the stakeholders involved in the system. The WEEE Directive Recast makes use of the term third party to relate stakeholders that are not a producer, importer or consumer (Table 13). Third parties can be represented by Wecycle, per example, that works on producer's behalf on WEEE collection and treatment. In that case, Wecycle has an active role in the system and represents several other secondary stakeholders. Concerning the secondary stakeholders, many third parties are involved, acting on diverse activities along the WEEE treatment process. However, those activities do not have adequate control. It becomes necessary to clearly define these stakeholders, so adequate and secure procedures are applied.

Table 13: Use of term third parties to correspond to different stakeholders in the WEEE Directive Recast [50]

WEEE Directive Recast	
Article 5: Separate collection	*Member States may require that the WEEE deposited at collection facilities is handed over to producers or third parties acting on their behalf , for purposes of preparing for re-use*
Article 7: Proper treatment	*Member States shall ensure that producers or third parties acting on their behalf set up systems to provide for the recovery of WEEE using best available techniques.*
Article 11: Recovery targets	*Member States shall ensure that producers or third parties acting on their behalf keep records on the weight of WEEE, its components, materials or substances when leaving (output) the collection facility, entering (input) and leaving (output) the treatment facilities and when entering (input) the recovery or recycling/ preparing for re-use facility.*

[48] Explanatory notes, goal
[49] 1998 Decree, Explanatory note, Introduction
[50] On Article 7, the term recovery is related to any kind of proper treatment WEEE can suffer

Figure 15 presents an exemplification of a Dutch WEEE System that considers the stakeholders' inclusion and the interactions that should be adequately recognised and tracked by legislation.

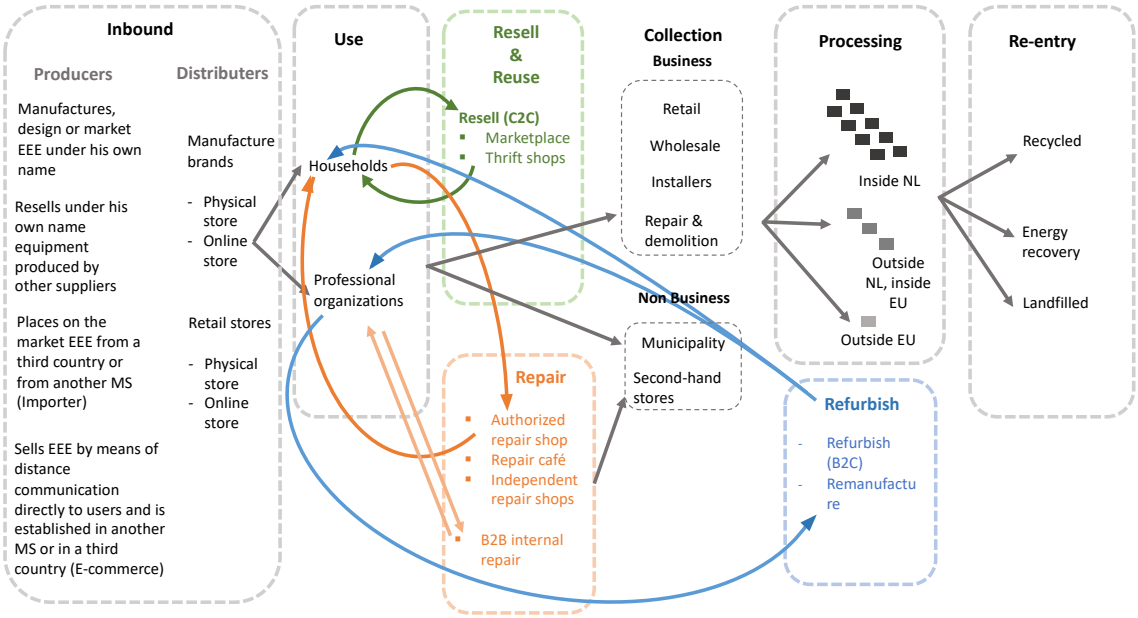

Figure 15: Dutch WEEE System with stakeholders inclusion

5.4.3 Reporting obligation referred to all circular activities

The full mapping of the stakeholders involved in the WEEE System also allows a higher information gathering. Data collection is a fundamental tool to measure the system efficiency and to track if proposed improvements are being successful.

Currently, NWR collects information from registered stakeholders. For the parties that are not registered acquire information becomes an issue. Despite the requirement that third parties have obligations to report on behalf of the represented stakeholder, this is not certain to happen in such a strict way.

5.4.4 Targets establishment following the waste hierarchy

In the 1996 European Parliament Resolution, the concept of waste management hierarchy was already existent. *"In relation to waste management, the Community will update the present waste strategy in the light of developments since 1989 and base the new Community Waste Strategy on the following hierarchy: 1. Prevention; 2. Reuse; 3. Recycling/biomethanisation/composting; 4. Incineration with energy recovery; 5. Landfill"* (European Parliament, 1996).

In the majority of the above-presented directives and legislation, the waste hierarchy is part of the framework. However, although the policies regarding waste evolved to foster societal and environmental demands, the waste management system has not been following this direction, focusing on the collecting system structure and the achievement of recycling and recovering targets. The WEEE Directive Recast considered the continuous WEEE growth, with targets update, coverage of a higher number of products and stricter monitoring requirements. Nonetheless, an evolution of requirements that contemplate the waste hierarchy is not in place.

The full implementation of the waste hierarchy framework cannot be satisfactorily measured since targets are only applied for recycling and energy recovery. The narrow target definition is based on the fact that recycling definitions are broad, relating to diverse forms of products or materials reuse. However, to make use of information-based instruments to estimate the waste management progress and further adoption of circular methods, MS need to first control and estipulate targets to all types of actions, starting from waste prevention.

Without established goals, it becomes challenging to incentivise stakeholders to act and also to gather investments. According to the EU Action Plan for the Circular Economy (European Commission, 2015): "*The development of the circular economy will also require public and private sources of financing to scale up improved technologies and processes, develop infrastructure and increase cooperation between actors in the value chain. (...) including support for reuse and repair, improved production processes, product design and SMEs."* However, it is not possible to evaluate projects success without having adequate measurement to monitor progress, especially when projects are novelties, not following business as usual.

6. Result 2: Critical reflections over the transition of the Dutch WEEE System into CE 3.0 principles

The key point of the MLP is that system transition occurs through the interplay between processes at different levels (Geels, 2007). Therefore, this chapter makes a critical reflection on the social and economic factors that interplay with the further implementation of CE practices in the WEEE System, as presented in section 3.3. Such considerations are based on the outcomes found in chapter 5 due to the analysis of WEEE legislation, Dutch WEEE System and stakeholders' interviews.

6.1 Economic factors

6.1.1 Financial incentives to promote circularity actions

The EPR policy main proposal is to direct the responsibility of products EoL to producers and importers, including financial responsibility. However, the promotion of appropriate waste management exposes concerns regarding extra financial spending. The 1998 Dutch Decree tried to diminish the stakeholders' financial concern showing waste management as an economic opportunity due to benefits promoted by an economy of scale, reflecting CE 2.0 concepts. *"This is on the one hand due to possible economies of scale with a larger range of devices to be processed. And on the other hand, due to improvements in reprocessing technology. Processing costs are expected to decrease as sharper contracts can be concluded by producers or importers. Producers and importers are also expected to be encouraged to develop products that are more suitable for reprocessing ("design for recycling")."*[51]

The focus on following an economy of scale method enabled recycling to be the primary treatment technique, followed by energy recovery. Furthermore, the processing conducted on a large scale mainly depends on shredding technologies. Due to efficiency matters, materials dismantling is mostly mechanical, giving less priority to the promotion of products and materials value retention (see section 5.3.5). The processor involved at the WEEE System are organisations that have profits based on material selling to recycling companies. In this case, profit generation by an economy of scale is mostly implemented.

Therefore, recycling is the lower-cost solution (Griese et al., 2004), compared with other R strategies, and its process complies with the environmental regulations and recovers a limited number of materials like metals and plastics. Moreover, promote activities that ensure products

[51] Explanatory notes, 9. Financial aspects

shorter loops as reuse, repairing, or refurbishing imply in additional costs associated with ensuring item's quality and safe working conditions.

The financial structure of the WEEE System does not make favourable to actors promote options that consider products higher value retention. Actors involved in the WEEE System expose that financial factors endorse the dominance of recycling measures. Producers consider products high aggregated value as a starting point to consider a repair option (section 5.3.4). At the same time, processors financially rely on WEEE processing and dismantling, retaining value over the recovered materials or energy return and having a partnership with recycling companies (section 5.3.6). In this case, the mostly implemented eco-design are the ones enforced by legislation, as Direct 2009/125/EC for of eco-design requirements for energy-related products (European Parliament, 2009) (section 5.3.5). Such behaviour has, as a consequence, the producers' choice to follow minimum standards. Despite the legislation shows ambition, its translation into practical actions are still slow, limiting innovation.

Furthermore, for the producers, the effort in investing in innovation is not paid off by the WEEE System. Producers are responsible for EEE production and hold a fundamental innovation role in developing and promoting eco-design concepts. However, from their perspective, the WEEE System does not recognise the effort of investing in R&D. The complaint consists that the Dutch WEEE System does not apply a modulating fee. For producers, such criteria do not incentivize innovation. Products should have more individual incentives, and the implementation of a fee modulation can promote more efficient value retention (section 5.3.9).

In an attempt to incentivize innovation, the EU Commission (European Commission, 2015) proposed: *"encourage better product design by differentiating the financial contribution paid by producers under extended producer responsibility schemes on the basis of the end-of-life costs of their products. This should create a direct economic incentive to design products that can be more easily recycled or reused".* However, such measures are not taken into effect in the Netherlands.

6.1.2 Business model

The exploration of different business models can promote circular economy strategies based on reselling, reuse or refurbishing instead of recycling. One of the expected effects is the supply expansion of reused items and a demand contraction for new products (Manuel González, Rodríguez, & Pena-Boquete, 2017). The changes in supply and demand can reduce the costs

of promoting close-loop practices. Hence, new market behaviour can generate changes in the welfare of consumers and producers.

The transition into a product-service system (PSS) can generate the development of more durable and repairable products. This model increases the involvement of the producers with the product during its use (maintenance, upgrade) and after use phases (take back, repair, recycling). According to Stahel (2013), the service-life extension of goods is more profitable and resource-efficient, which is consistent with the world's finite resource base. Extending product-life reduces depletion of natural resources and consequently waste. Such considerations are compatible with the CE 3.0 focus, on slowing and reducing material use and changing production patterns. Therefore, there is a necessity to incentivise economic models that produce value differently than the dominant production and consumption market structure.

In the ICT environment, innovative business models based on services that include hardware and software maintenance are not new. Xerox, for example, already opted for a leasing approach in the B2B market. The company maximized the use of components by designing products for easy disassembly, durability, reuse and recycling, offering the same guarantee for products regardless of the reprocessed content. Such model considers the customer purchases a service rather than the equipment (ACCR, 2012).

On a B2C level, actors have started to tackle new business models in a bottom-up approach by introducing models that consider reuse, repair and remanufacture instead of product replacement (Stahel, 2013). Considering the lifespan of personal computers (PCs) is shorter for corporations use than for households, those become recipients of second-hand products from large corporations (Intlekofer et al., 2010). Moreover, as presented in section 5.3.4, the interviewed processor holds an ICT refurbish company recognizing that laptops, for example, can many times present easy repair, allowing consumers to keep their equipment for a longer period. However, some policy and social barriers make this approach difficult to happen.

On policy-related matters, organisations that promote reuse must compete with recyclers markets. A lack of legislation for reuse is a substantive barrier to the creation of business models that prioritize close loops. Such a barrier can be attributed to the WEEE Directive where MS do not allocate reuse towards their national targets. While reuse standards do not get proper recognition, it is difficult to refer to standard definitions of good reuse practices and to enhance transparency and quality control in the sector (Kissling et al., 2013).

6.2 Social factors

6.2.1 Promotion of consumer's responsibility

As presented in chapter 5, despite the Dutch WEEE System promotes an entire structure composed of diverse stakeholders to properly manage WEEE, the role of consumers in this process is critical. Consumer personal responsibility is a relevant point on the promotion of products value retention, involving their choice for products that provide a longer life cycle, their disposition to resell or repair equipment and to not comply with consumption trends.

The EPR already address the responsibility for products lifetime to producers. However, the WEEE System pushes the responsibility to consumers (see section 5.3.2 and WEEE Directive recast, article 14) alleging that legislation established consumers contribution and by assuming that if EEE still has valued the consumer will promote its life extension. However, consumers still find barriers in cooperating with the system. Consumer's proactiveness to collaborate needs to be supported by the WEEE System since the primary responsibility of promoting circularity considering the EPR principles is from the producers and not from consumers. Improve the promotion of consumer's responsibility implies in making clear to consumers that they are not locked in a model that pushes the "throw it away" behaviour. Options must be clear and possible to be followed without involving complicated efforts or processes.

As shown in section 3.1, the WEEE legislation concentrates in promoting a regime in which management improvements focus on the consumption growth regime and is careless in concerning about prevention and efficiency use, that comply with a sustainable innovation process. As confirmed in section 5.4, the system's compliance with the CE principles still focus on output measures and promotes results regarding longer loop value retention (recycling and energy recovery).

Provide necessary infrastructure and information are two actions that are already the responsibility of the WEEE System. However, the current efforts are not enough. Legislation and producers must lead actions that extend the life of products, helping consumers to make better choices and promote products higher value retention.

Currently, infrastructure relies on WEEE collective points (see Figure 9) that focus on collecting WEEE and processing for recycling. Figure 15 presents the WEEE System considering stakeholders that can promote products life extension. However, as previously discussed, not all stakeholders are acknowledged by the system. In such case, legislation can promote measures that aid consumers by improving the system in including stakeholders that

promote repair, refurbish and remanufacture centres. Also, considering a higher integration between producers and consumers, the effort of extending products lifespan can be enforced by longer warranty periods for consumers, for example. Promote an infrastructure that facilitates consumers to maintain or improve their product's performance is essential. Repair and resell services need to be reliable and regulated, assuring quality and guarantee.

Considering the offering of more refurbish and repair centres, Maitre-Ekern & Dalhammar (2016) defend the possibility of consumers get their products repaired by non-certified repairers. Allowing non-certified centres to operate is in line with the short loops principles in which allows small or community-based repairers to operate, lowering costs and empowering local professionals. Such factors can help to change the setting of consumers to dispose of and buy new products since consumers can make a choice for new products because it is cheaper and more comfortable to acquire. However, producers do not agree with such mechanism (see section 5.3.3) and fight against legislative efforts in requiring from producers any kind of support, like tools or manuals, for repair centres. The hold of producers in promoting a higher number of repair centres reduces the availability to consumers to be able to prolong their EEE use. In that case, it is necessary to consider a higher integration between legislation, producers and repair centres. Moreover, as presented in section 6.1.2 business models that promote short loops still lack in legislative support, like standard definitions for the practices and target specifications.

Another point that producers can help consumers in extending product lifetime is by offering longer warranties. The majority of European MS provide a legal warranty of two years, while some countries, like Ireland, have raised it six years for all products. The Netherlands does not provide for a fixed legal warranty, grounding the warranty time to the expected lifespan of the product category (Maitre-Ekern & Dalhammar, 2016). Such behaviour connects with the business point of view that repair some products is not advantageous, in which it is better to acquirer a new product and recycle the old one (see section 5.3.4). Therefore, the consumer’s engagement is not fully supported by producers since the producer-consumer relation is still based on product selling models. That case shows that producers, despite pushing responsibility to consumers, still mostly rely on consumer's consumption patterns and profits from new products (section 5.3.7).

Considering information provision to consumers, the WEEE System superficially covers the topic by awareness campaigns about correct WEEE disposal and on destination options for consumer’s equipment (section 5.3.2 and 5.3.4), confirming the WEEE System focus on

promoting recycling activities and not on proving to consumers options that can increase products value retention. Consumers' choices have a significant effect on the promotion of devices' efficient use. Producers and retailers must promote a closer and long-term relationship with clients, allowing them to request guidance and further information.

Information can help consumers to make more assertive choices and to have the discernment in what kind of product's feature to focus. Such features can be price over quality, possibility to upgrade the product, modularity design that encourages repair and remanufacturing and awareness promotion about product care. The consumer needs to have a clear perception of the real value of the acquired product. Maitre-Ekern & Dalhammar (2016) argue that information can induce consumers to choose, within one product group, a more expensive item that has a longer lifespan, is more energy-efficient or have the benefit of a longer legal warranty. Such characteristics may contribute to make durability a strong sales argument and aid also to avoid products that have low quality and are difficult to repair or have a short lifespan (section 5.3.4). The aims are increasing the power of consumers to make informed choices and making the reparability of products a sales criterion. Consumers purchasing power can end up pushing producers to develop products with higher circularity features.

7. Discussion

The 2012 WEEE Directive Recast directly states: "*The purpose of this Directive is to contribute to sustainable production and consumption by, as a priority, the prevention of WEEE and, also, by the re-use, recycling and other forms of recovery of such wastes to reduce the disposal of waste and to contribute to the efficient use of resources and the retrieval of valuable secondary raw materials*"[52]. Waste legislation always presented the importance of prioritising waste hierarchy. However, the regulation translation into actions reveals a system that focuses more on the efficient use of recycled resources than on prevention or the reduction of WEEE disposal.

The Dutch WEEE System analysis showed that despite the legislation explicitly recognizing the priority of activities that follow the waste hierarchy, the system does not follow that rule. As presented in Table 8 and Table 8, the WEEE legislation only established targets for WEEE collection, recycling, and recovery. Moreover, the System's primary focus is on improving the collecting rate, to achieve the demanded goal, as highlighted in section 5.3.1.

The waste legislation had as initial concern the phasing out of landfilling and reducing incineration, transitioning from the take-make-dispose regime mode. However, it was expected that the evolution of WEEE policies would encourage actions regarding higher circularity principles. The EPR had the intention to support the development of a policy framework that could stimulate a sustainable mode of production and consumption. Nevertheless, the WEEE Directive used the EPR application to promote economic benefits from the financial burden of public waste management, not putting enough effort into supporting a regime change toward circular economy (Tong & Yan, 2013).

The measures that currently guide the Dutch WEEE System focus more on creating a waste management system than furthering sustainable innovation and engaging actors at different levels in supporting the outlined aims (Lauridsen & Jørgensen, 2010). Therefore, it is necessary to observe why the Dutch WEEE System does not comply with further circular economy practices. The absence of targets that push the system to comply with the waste hierarchy levels is a significant factor that breaks stakeholders' actions (Cole et al., 2019; Re-use and recycling European Union social enterprises, 2015). The legislation, apart from waste collection targets, only demands compliance of activities connected with recycling and recovery. Such demands

[52] 2002 WEEE Directive, Article 6

are favourable to the stakeholders since recovery activities show benefit over other waste hierarchy options since production models are not profoundly affected and the recycling structure, allows the process to happen in an economy of scale (Cole et al., 2019). The stakeholders' argument that they already successfully fulfil the established recovery targets (see Table 12), and other demands compliance is not mandatory.

Activities related to medium loops require higher arrangements involving extra stakeholders in the WEEE System, and the materials process cannot occur at such a large scale as on the recycling model. Short loop activities promote extending the products' lifespan. Such actions incentivize the reduction of inputs, considering resources' use during the manufacturing of new appliances, and consumption (Kissling et al., 2012). However, short loops activities face barriers regarding consumer avoidance towards purchasing second-hand products.

Promote medium and short loop actions is an essential step towards the efforts of improving the waste management structure. The legislation needs to find mechanisms to emphasise the waste hierarchy compliance, not just following actions that are easier to execute and bring a higher financial return. Stakeholders need to focus on the evolution of the waste management structure, establishing measures that promote the further adoption of practices that encourage products' higher retention. As signalized in section 6.1.1, the lack of financial incentives implemented by the WEEE legislation, like modulated fees, are a barrier to producers promote innovation. Furthermore, do not encourage business models that shift from stimulating high consumption levels, and incentivize reuse and repair is another barrier that reduces the promotion of circular options in the market.

Furthermore, when it comes to legislative support to promote changes in the WEEE System, the WEEE Directive is not the only route that can endorse circularity improvement. Along with the establishment of the WEEE System, other legislations were relevant to supplement the WEEE Directive. During the stakeholders' interviews, two specific topics were of great concern for producers: hazardous materials and EEE energy-saving (see section 5.3.5). Although such matters are addressed on the 2012 WEEE Directive Recast[53], the Directive 2009/125/EC (European Parliament, 2009) established a framework for setting eco-design requirements for energy-related products, and the Directive 2002/95/EC (European Parliament, 2003a) concerns the use of certain hazardous substances, requiring the substitution of banned chemicals in respect to all EEE. Such Directives highlighted WEEE management's importance and enforced

[53] 2012 WEEE Directive Recast paragraph 4

action. Therefore, it is necessary to consider supplementary legislation that better regulates and supports the application of higher circular principles in WEEE management.

Moreover, the lack of a stakeholder dedicated to secure an agenda that promotes innovation makes the requests regarding such matters to be under secondary considerations. It becomes necessary to point a stakeholder in charge of promoting and supporting innovation within the Dutch WEEE System. Such action pushes the establishment of improvements in the system. An example is the creation of the Stichting OPEN (see section 5.3.9). The new management body aims to improve the WEEE System, ensuring the effective and efficient achievement of legal objectives (targets). Therefore, it is necessary to consider: Who supports higher circular actions within the WEEE System?

The promotion of higher circular actions can be introduced by the government in a top-down direction or be an inclusive and participatory process considering a broader set of stakeholders and societal groups. Geels (2010) states the direction from which change occurs depends on the type of transition. If the transition concerns technical changes, the governments should do this with the support of technical experts and committees. If the transition considers a broad social transformation process, involving consumer behaviour and lifestyles, then a participatory process with broader stakeholders and societal groups might be a better path.

According to Lauridsen & Jørgensen (2010), with the growing pressure on available resources and the threats posed by climate change, even more policies, and top-down initiatives can be expected for transitions promotion. However, currently, many stakeholders, mostly in the informal sector, are already mobilized in promoting circularity principles without the WEEE System support or recognition (see section 6.1.2). This shows that changes regarding the adoption of CE 3.0 are not a strict top-down process. In both transition scenarios, led by government or participatory process, legitimacy and public support will be essential to encourage financial investments and policy changes, in which narratives will have to be followed by investments, innovations, and policies (Geels, 2010).

Furthermore, the WEEE System still puts great responsibility for promoting circularity over the consumers (section 5.3.2). However, the legislation entails responsibility for producers and not consumers. The matter extends if producers have an interest in providing mechanisms that enable consumers to prolong their products' lifespan. The current product consumption still follows market trends and consumers' consumption behaviour, characterizing a market path dependence, and orienting incremental innovation into predictable trajectories (Geels, 2010).

Therefore, consumers still find barriers in applying higher value retention products, becoming necessary to empower them as relevant stakeholders on the WEEE System (see section 6.2.1). The promotion of consumer's responsibility needs to be supported by the increased offering of information and infrastructure to evaluate the best destination option for their product and push the market into necessary changes.

7.1 Study limitations and further research

This thesis adopted a qualitative case study approach providing an examination of the Dutch WEEE System considering stakeholders' position about the subject. However, the findings' relevance needs to be confirmed by further studies, differing from this thesis in terms of scope and methodology.

First, this thesis considered a limited scope. First, this thesis considered a limited scope. Considering the methodology, the approach provided sufficient room for the explorative examination of the Dutch WEEE System. The reach of saturation point was considered when stakeholders advocated from similar perspectives and specific subjects dominated the discourse. Data saturation is reached when there is enough information to replicate the study and the ability to obtain additional new information has been attained (Fusch & Ness, 2015). In this case, the code generated was consistent with the research question, and the theoretical position and analytic framework adopted. However, there was some limit to its scope, allowing for some degree of generalisation.

Despite consumer's responsibility representing a relevant subject of analysis in this research, the interview's focus was on the stakeholders connected with the WEEE System's operational part, not including consumers. Another scope limitation was the focus on the ICT product category. The WEEE System considers a diverse set of products with different characteristics. To further implement actions that change the way that society, producers, and governments deal with the waste generation, it is necessary to consider the specificities of each EEE group.

Moreover, improving sustainability through regime transitions form a rich and challenging topic that will remain socially relevant for decades to come, but can also benefit from dialogues between various approaches (Geels, 2010). The MLP framework helps to analyse how the WEEE System should consider proposals to improve product circularity. However, since the perspective looks to capture the topic complexity, many other variables need to be considered.

Despite the CE evolution, its translation into practical actions are not equally evolving (Kirchherr et al., 2018). The implementation of further steps that stimulate consumption reduction, reuse of materials, and strategies that encourage higher value retention materials is still deficient. It is expected that this thesis can contribute to the discussion of EPR application in the WEEE legislation and can provide a sound basis for further research efforts.

Insights gained from evaluating the impact of the WEEE Directive on the Dutch WEEE System may also be applied to the legislation and WEEE System of others MS and impact the strategies connected with the development of new business models and EEE design and production. Furthermore, more empirical insights can promote the efficacy of EPR and the systems it creates. Different legislative provisions, from other European countries, can bring other practical forms of promoting products higher value retention, as Spain that is already considering reuse target in their WEEE legislation (Manuel González et al., 2017).

8. Conclusion

Developed countries, including the Netherlands, have achieved significant results for waste management to lead to sustainable development, by implementing CE principles through legislative proposals. However, the CE concept has been evolving over the years, in which, currently, CE 3.0 deals with challenges connected with resource depletion and resources value retention through narrowing material loops. Therefore, this research intended to analyse the Dutch WEEE System and evaluate how it can promote higher value retention of products following the CE 3.0 principles. Two sub-research questions aid the study development.

First, an analysis of the European and Dutch legislation regarding WEEE management and the translation of the legislation in an operational structure provided an understanding of the Dutch WEEE System and allowed to answer the first sub-research question *How is the Dutch WEEE System currently organised?*

The results showed the waste hierarchy principles endorsed by legislation are not followed. The Dutch WEEE System still focuses mainly on effectively achieve the targets of material collection, recycling and recovery, practices promoted by CE 2.0 principles. However, as presented in Figure 5, the EPR should promote efficient WEEE management and stimulate prevention and reuse (Rs short loops), supporting an innovation-oriented regime.

Therefore, to support the promotion of higher circular principles and direct the WEEE System in adopting an innovation-oriented regime, this research proposed four actions that have an impact on the WEEE legislation and the Dutch WEEE System (see section 5.4): (1) provide a clear definition of the circular actions; (2) officially recognise all the stakeholders present at the WEEE System; (3) require information reporting from all stakeholders involved with any circular action and (4) establish targets for the other circularity actions besides recycling and recovery.

Nonetheless, following the multi-level perspective, promoting only technical changes on the WEEE legislation and in the system's, structure is not enough to the Dutch WEEE System successfully transition into the adoption of CE 3.0 principles and promote the co-evolution of innovation and management regimes. Therefore, a critical reflection over the WEEE System considered the socio-technical environment that embeds the Dutch WEEE System, addressing the second sub-research question, *What socio-technical factors act as barriers on the Dutch WEEE System transition to CE 3.0?*

Economic and social factors presented barriers to adopting circular strategies (see chapter 0), especially for the ICT product category. Lack of financial incentives, difficulty in promoting new business models and consumer responsibility present barriers that need to be considered in developing policies and strategies that support the system compliance with CE 3.0 concepts.

Henceforth, to answer this thesis's overall research question, *How can the Dutch WEEE System, in the case of product category ICT, transition to CE 3.0 through promoting the higher value retention of products?* This research recommends improvements to be applied in the Dutch WEEE System (sub-question 1) and presented relevant socio-technical considerations that act as barriers to the systems' transition (sub-question 2).

9. Bibliography

ACCR. (2012). *The management of WEEE. A guide for local and regional authorities*. (J. P. Hannequart, Ed.), *Association of Cities and Regions for Recycling*. Brussels.

Ayres, R. U., & Peiró, L. T. (2013). Material efficiency: Rare and critical metals. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *371*(1986).

Balde, C. P., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2017). *The global e-waste monitor 2017: Quantities, flows and resources*. *United Nations University, International Telecommunication Union and International Solid Waste Association*.

Basel Action Network. (2018). Holes in the Circular Economy: WEEE Leakage from Europe, 1–110.

Blomsma, F., & Brennan, G. (2017). The Emergence of Circular Economy: A New Framing Around Prolonging Resource Productivity. *Journal of Industrial Ecology*, *21*(3), 603–614.

Bourguignon, D., & Bonafè, S. S. (2018). *Circular economy package: Four legislative proposals on waste*. *European Parliament Research Service*.

Bryman, A. (2012). *Social research methods* (4th ed.). Oxford University Press.

Cole, C., Gnanapragasam, A., Cooper, T., & Singh, J. (2019). An assessment of achievements of the WEEE Directive in promoting movement up the waste hierarchy: experiences in the UK. *Waste Management*, *87*, 417–427.

Cox, J., Griffith, S., Giorgi, S., & King, G. (2013). Consumer understanding of product lifetimes. *Resources, Conservation and Recycling*, *79*, 21–29.

Cuppen, E. (2011). Diversity and constructive conflict in stakeholder dialogue: considerations for design and methods. *Policy Science*, *45*(1), 23–46.

Defillet, D., Cosyn, L., & Vanderschaeghe, P. (2013). *Benchmark WEEE systems in Europe*.

European Commission. (2015). *Closing the loop - An EU action plan for the Circular Economy - (COM/2015/614 final)*. Brussels.

European Parliament. (1975). *Council Directive on waste 75/442/EEC of 15 July 1975*. *Official Journal of the European Union*.

European Parliament. (1989). *A community strategy for waste management*.

European Parliament. (1996). *Official Journal of the European Communities 96/C 362*. *Official Journal of the European Union* (Vol. 39).

European Parliament. (2003a). *Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment*. *Official Journal of the European Union*.

European Parliament. (2003b). *Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)*. *Official Journal of the European Union*.

European Parliament. (2008). *Directive 2008/98/EC of the European Parliament and of the council of 19 November 2008 on waste and repealing certain Directives*. *Official Journal of the European Union*.

European Parliament. (2009). *Directive 2009/125/EC of the European Parliament and of the council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (recast)*. *Official Journal of the European Union*.

European Parliament. (2012). *Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (WEEE) (recast)*. *Official Journal of the European Union*.

European Parliament. (2018). *Directive (EU) 2018/849 of the European Parliament and of the Council of 30 May 2018*. *Official Journal of the European Union*.

Eurostat. (2020). Waste electrical and electronic equipment (WEEE) by waste management operation. Retrieved June 1, 2020, from http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do

Fusch, P. I., & Ness, L. R. (2015). Are We There Yet? Data Saturation in Qualitative Research. *The Qualitative Report*, *20*(9), 1408–1416.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, *31*(8–9), 1257–1274.

Geels, F. W. (2007). Analysing the breakthrough of rock "n" roll (1930-1970) Multi-regime interaction and reconfiguration in the multi-level perspective. *Technological*

Forecasting and Social Change, *74*, 1411–1431.

Geels, F. W. (2010). Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. *Research Policy*, *39*, 495–510.

Ghisellini, P., Cialani, C., & Ulgiati, S. (2016). A review on circular economy: the expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, *114*, 11–32.

Gidarakos, E., Basu, S., Rajeshwari, K. V., Dimitrakakis, E., & Johri, C. R. (2012). E-waste recycling environmental contamination: Mandoli, India. *Waste and Resource Management*, *165*(1), 45–52.

Griese, H., Poetter, H., Schischke, K., Ness, O., & Reichl, H. (2004). Reuse and lifetime extension strategies in the context of technology innovations, global markets, and environmental legislation. *IEEE International Symposium on Electronics and the Environment*, 173–178.

Huisman, J., van der Maesen, M., Eijsbouts, R. J. J., Wang, F., Baldé, C. P., & Wielenga, C. A. (2012). The Dutch WEEE Flows. *United Nations University, ISP -SCYCLE*.

Intlekofer, K., Bras, B., & Ferguson, M. (2010). Energy Implications of Product Leasing. *Environmental Science & Technology*, *44*, 4409–4415.

Islam, M. T., & Huda, N. (2018). Reverse logistics and closed-loop supply chain of Waste Electrical and Electronic Equipment (WEEE)/E-waste: A comprehensive literature review. *Resources, Conservation and Recycling*, *137*, 48–75.

Kalimo, H., Lifset, R., Atasu, A., Van Rossem, C., & Van Wassenhove, L. (2015). What Roles for Which Stakeholders under Extended Producer Responsibility? *Review of European, Comparative and International Environmental Law*, *24*(1), 40–57.

Kirchherr, J., Piscicelli, L., Hekkert, M. P., Bour, R., Kostense-Smit, E., Muller, J., … Hekkert, M. (2018). Barriers to the Circular Economy: Evidence From the European Union (EU). *Ecological Economics*, *150*, 264–272.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232.

Kissling, R., Coughlan, D., Fitzpatrick, C., Boeni, H., Luepschen, C., Andrew, S., & Dickenson, J. (2013). Success factors and barriers in re-use of electrical and electronic

equipment. *Resources, Conservation and Recycling*, *80*, 21–31.

Kissling, R., Fitzpatrick, C., Boeni, H., Luepschen, C., Andrew, S., & Dickenson, J. (2012). Definition of generic re-use operating models for electrical and electronic equipment. *Resources, Conservation and Recycling 65*, *65*, 85–99.

Lauridsen, E. H., & Jørgensen, U. (2010). Sustainable transition of electronic products through waste policy. *Research Policy*, *39*(4), 486–494.

Leclerc, S. H., & Badami, M. G. (2019). Extended Producer Responsibility for E-waste Management: Policy Drivers and Challenges. *Journal of Cleaner Production*.

Lindhqvist, T. (2000). *Extended Producer Responsibility in Cleaner Production: Policy Principle to Promote Environmental Improvements of Product Systems*. IIIEE, Lund University.

Maitre-Ekern, E., & Dalhammar, C. (2016). Regulating planned obsolescence: A review of legal approaches to increase product durability and reparability in Europe. *Review of European, Comparative and International Environmental Law*, *25*(3), 978–394.

Manuel González, X., Rodríguez, M., & Pena-Boquete, Y. (2017). The social benefits of WEEE re-use schemes. A cost benefit analysis for PCs in Spain. *Waste Management*, *64*, 202–213.

Minister of Housing Spatial Planning and the Environment. (1998). Decree on the removal of white and brown goods of 21 April 1998. Retrieved April 6, 2020, from https://zoek.officielebekendmakingen.nl/stb-1998-238.html

Monier, V., Hestin, M., Cavé, J., Laureysens, I., Watkins, E., Reisinger, H., & Porsch, L. (2014). *Development of Guidance on Extended Producer Responsibility (EPR): Final Report*. *European Commission – DG Environment*.

National WEEE Register. (2019). *NWR 2018 Report*.

National WEEE Register. (2020). Treatment operators and exporters. Retrieved March 22, 2020, from https://www.nationaalweeeregister.nl/english/treatment-operators.html

Ness, D. (2008). Sustainable urban infrastructure in China: Towards a Factor 10 improvement in resource productivity through integrated infrastructure systems. *International Journal of Sustainable Development & World Ecology*, *15*, 288–301.

NVMP Association. (2019). Retrieved December 6, 2019, from https://www.nvmp.nl/over-

nvmp/vereniging-nvmp/

NVMP Mission. (2019). Retrieved December 9, 2019, from https://www.nvmp.nl/over-nvmp/vereniging-nvmp/

NVMP Structure. (2019). Retrieved December 9, 2019, from https://www.nvmp.nl/over-nvmp/vereniging-nvmp/

Ongondo, F. O., Williams, I. D., & Cherrett, T. J. (2011). How are WEEE doing? A global review of the management of electrical and electronic wastes. *Waste Management*, *31*, 714–730.

Ongondo, F. O., Williams, I. D., Dietrich, J., & Carroll, C. (2013). ICT reuse in socio-economic enterprises. *Waste Management*, *33*, 2600–2606.

Organization of Producer Responsibility for E-waste Netherlands. (2019). Stichting OPEN. Retrieved April 12, 2020, from https://stichting-open.org/

Re-use and recycling European Union social enterprises. (2015). *Putting re-use and repair at the heart of the EU's Circular Economy Package*.

Reike, D., Vermeulen, W. J. V., & Witjes, S. (2018). The circular economy: New or Refurbished as CE 3.0? — Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options. *Resources, Conservation and Recycling*, *135*, 246–264.

Seager, D., Hieronymi, K., McIntrye, K., Guilcher, H., & Janse Van Rensburg, R. (2012). Producer responsibility when WEEE has a value. *Electronics Goes Green 2012+*, 1–6.

Stahel, W. R. (2013). Policy for material efficiency - Sustainable taxation as a departure from the throwaway society. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *371*(1986).

State Secretary for Housing Spatial Planning and the Environment. (2004). Management of electrical and electronic equipment. Retrieved March 21, 2020, from https://wetten.overheid.nl/BWBR0016990/2013-01-02#Opschrift

State Secretary of Infrastructure and the Environment. Regulation on waste electrical and electronic equipment - IENM/BSK-2013/287023 (2013). Netherlands.

Tojo, N. (2001). Effectiveness of EPR Programme in Design Change Study of the Factors that Affect the Swedish and Japanese EEE and Automobile Manufacturers. *IIIEE*

Reports, 19.

Tong, X., & Yan, L. (2013). From Legal Transplants to Sustainable Transition: Extended Producer Responsibility in Chinese Waste Electrical and Electronic Equipment Management. *Journal of Industrial Ecology*, *17*(2), 199–212.

Van Halen, C., Vezzoli, C., & Wimmer, R. (2005). *Methodology for product service system innovation: how to develop clean, clever and competitive strategies in companies*. Amsterdam: Uitgeverij Van Gorcum.

Walls, M. (2006). *Extended Producer Responsibility and Product Design: Economic Theory and Selected Case Studies*.

Wecycle. (2019). Feiten & Cijfers 2018. Retrieved March 21, 2020, from https://www.wecycle.nl/feiten-en-cijfers#

Whalen, K. A., Milios, L., & Nussholz, J. (2017). Bridging the gap: Barriers and potential for scaling reuse practices in the Swedish ICT sector. *Resources, Conservation & Recycling*, *135*, 123–131.

Wong, M. H., Wu, S. C., Deng, W. J., Yu, X. Z., Luo, Q., Leung, A., … Wong, A. H. (2007). Export of toxic chemicals-A review of the case of uncontrolled electronic-waste recycling. *Environmental Pollution*, *149*(2), 131–140.

Yang, J., Lu, B., & Xu, C. (2007). WEEE flow and mitigating measures in China. *Waste Management*, *28*, 1589–1597.

Yin, R. K. (2003). *Case Study Research: design and methods* (3rd ed.). Thousand Oaks: Sage.

Yoshida, F., & Yoshida, H. (2010). Japan, the European Union, and waste electronic and electrical equipment recycling: Key lessons learned. *Environmental Engineering Science*, *27*(1), 21–28.

Zoeteman, B. C. J., Krikke, H. R., & Venselaar, J. (2010). Handling WEEE waste Hows: On the effectiveness of producer responsibility in a globalizing world. *International Journal of Advanced Manufacturing Technology*, *47*(5–8), 415–436.

10. Appendix

Appendix I: Categories of electrical and electronic equipment covered by Directive 2012/19/UE (Annex II) until 15 August 2018

1. Large household appliances

2. Small household appliances

3. IT and telecommunications equipment

4. Consumer equipment

5. Lighting equipment

6. Electrical and electronic tools (with the exception of large-scale stationary industrial tools)

7. Toys, leisure and sports equipment

8. Medical devices (with the exception of all implanted and infected products)

9. Monitoring and control instruments

10. Automatic dispensers

Appendix II: Categories of electrical and electronic equipment covered by Directive 2012/19/UE (Annex III) after 15 August 2018

1. Temperature exchange equipment

2. Screens, monitors, and equipment containing screens having a surface greater than 100 cm2

3. Lamps

4. Large equipment (any external dimension more than 50 cm) including, but not limited to:

Household appliances; IT and telecommunication equipment; consumer equipment; luminaires; equipment reproducing sound or images, musical equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and

control instruments; automatic dispensers; equipment for the generation of electric currents. This category does not include equipment included in categories 1 to 3

5. Small equipment (no external dimension more than 50 cm) including, but not limited to:

Household appliances; consumer equipment; luminaires; equipment reproducing sound or images, musical equipment; electrical and electronic tools; toys, leisure and sports equipment; medical devices; monitoring and control instruments; automatic dispensers; equipment for the generation of electric currents. This category does not include equipment included in categories 1 to 3 and 6.

6. Small IT and telecommunication equipment (no external dimension more than 50 cm)

Appendix III: Operations which may lead to recovery covered by Council Directive of 15 July 1975 on Waste 75/422/EC (Annex II B)

NB: This Annex is intended to list recovery operations as they are carried out in practice. In accordance with Article 4, waste must be recovered without endangering human health and without the use of processes or methods likely to harm the environment.

R1 Solvent reclamation/regeneration

R2 Recycling/reclamation of organic substances which are not used as solvents

R3 Recycling/reclamation of metals and metal compounds

R4 Recycling/reclamation of other inorganic materials

R5 Regeneration of acids or bases

R6 Recovery of components used for pollution abatement

R7 Recovery of components from catalysts

R8 Oil re-refining or other re-uses of oil

R9 Use principally as a fuel or other means to generate energy

R10 Spreading on land resulting in benefit to agriculture or ecological improvement, including composting and other biological transformation processes, except in the case of waste excluded under Article 2 (1) (b) (iii)

R11 Use of wastes obtained from any of the operations numbered R1 — R10

R12 Exchange of wastes for submission to any of the operations numbered R1 — R11

R13 Storage of materials intended for submission to any operation in this Annex, excluding temporary storage, pending collection, on the site where it is produced.

Appendix IV: Operations which may lead to disposal operations by Council Directive of 15 July 1975 on Waste 75/422/EC (Annex II A)

NB: This Annex is intended to list disposal operations such as they occur in practice. In accordance with Article 4, waste must be disposed of without endangering human health and without the use of processes or methods likely to harm the environment.

D1 Tipping above or underground (e.g. landfill, etc.)

D2 Land treatment (e.g. biodegradation of liquid or sludge discards in soils, etc.)

D3 Deep injection (e.g. injection of pumpable discards into wells, salt domes or naturally occurring repositories, etc.)

D4 Surface impoundment (e.g. placement of liquid or sludge discards into pits, ponds or lagoons, etc.)

D5 Specially engineered landfill (e.g. placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)

D6 Release of solid waste into a water body except for seas/oceans

D7 Release into seas/oceans including seabed insertion

D8 Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are disposed of by means of any of the operations in this Annex

D9 Physico-chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are disposed of by means of any of the operations in this Annex (e.g. evaporation, drying, calcination, etc.)

D10 Incineration on land

D11 Incineration at sea D12 Permanent storage (e.g. emplacement of containers in a mine, etc.)

D13 Blending or mixture prior to submission to any of the operations in this Annex

D14 Repackaging prior to submission to any of the operations in this Annex

D15 Storage pending any of the operations in this Annex, excluding temporary storage, pending collection, on the site where it is produced.

Appendix V: Interviews guideline

The interviews made for this research had different stakeholders as a target. Do this particularity, the questions were adapted to understand the position of specific stakeholders inside the WEEE System. Moreover, the following guideline was used as base to the interviews, but alterations were possible to be made in the course of the interview.

A. NVMP

NVMP Association represents over 1,800 producers and importers of electrical appliances and energy-efficient lighting in the Netherlands through its affiliated product foundations. NVMP is committed to the collection and high-quality recycling of waste electrical.

Initial check-up
✓*Confidentiality*
✓*Consent*

Introduction

The objective of the following questions is to understand how the Dutch WEEE System operates. Besides, the interview aims to get opinions about the WEEE legislation efficiency and how it can contribute with the circular economy principles and promote the materials higher value retention.

1. What were the initial demands that lead the organisation's creation?
2. How do you consider the NVMP importance on the WEEE management system?
3. Do you think costumes are aware of the importance of promoting the correct discard of their WEEE, especially ICT equipment (considering the items small size)? Or many of this equipment is still going to regular waste bins?
4. What actions can help on the promotion of WEEE correct destination? Do you promote campaigns to bring awareness to people to make the proper WEEE discard? Is there a specific budget for it? Does the legislation specify some actions to be followed?

5. How is the participation of repair and refurbish shops on the WEEE System? Does NVMP offer some support? Do the shops have to comply with some regulation?
6. Although the WEEE Directive considers the products reuse a priority over recycling and energy recover, these two last options are the ones mostly practised, being the only ones to have targets established by the WEEE policies. Do you agree with the prioritizing of recycling over other forms of action (reuse, resell, refurbish) that try to preserve the use of the product?
7. Do you think WEEE Management also involves the promotion of alternatives that avoid EEE to become WEEE? Like the promotion of EEE repairing and the use of second-hand products. What actions do you promote with your partners to promote that?
8. Usually, customers hold the decision on discard an EEE or giving it an extended lifetime by repairing or reselling. Do you believe the customer is the only stakeholder that should be entitled to take actions regarding extending EEE lifetime and avoiding more waste production? How can other stakeholders help in promoting that as well?
9. What are the actions taken by NVMP and the foundations for incentivizing the promotion of other circularity measures?
10. Are there stakeholders that should have more responsibilities and comply with rules? The producers, per example, should they have higher participation in the WEEE management process, besides paying the producers responsibility fee?
11. Do you engage with other stakeholders to know their opinions and requirements about the WEEE System?
12. How is the association engagement with the government?
13. Do you think the Dutch WEEE System efficiently addresses WEEE demands or improvements on the system need to be made?
14. Do you think society is making a new requirement related to sustainability and circularity that the WEEE System and policies still need to comply? What are those demands?
15. Does NVMP make benchmarking studies from other countries about best practices to manage WEEE?

B. Wecycle

Responsible for operational actions regarding WEEE management. Work with partners in activities like collection, sorting, dismantling, recycling and energy return.

Initial check-up

✓*Confidentiality*
✓*Consent*

1. Who are Wecycle main clients? You work for NVMP that is a collective system, do you attend individual producers?
2. After collection, to which location the e-waste is taken? What is the process WEEE pass by after the collection process?
3. After the sorting, what are e-waste destination options? Do you promote some assessment to check if WEEE can have the lifetime extended through repairing or if it can be refurbished?
4. On Wecycle website, you state that 95% of e-waste were given a reusable application. How do you define reusable application? Is it dismantling equipment and recycling the spare parts? What are the factors considered here?
5. What are the main challenges considering the collection and sorting process? What needs to be improved?
6. Do you think costumes are aware about the importance of promoting the correct discard of their WEEE, especially ICT equipment (considering the items have a small size)? Or many of this equipment is still going to regular waste bins?
7. What actions can help on the promotion of WEEE correct destination? Do you promote join campaigns with the municipalities to bring up people's awareness? Is there a specific budget for it? Does the legislation specify some actions to be followed?
8. Usually, customers hold the decision on discard an EEE or giving it an extended lifetime by repairing or reselling. Do you believe the customer is the only stakeholder that should be entitled to take actions regarding extending EEE lifetime and avoiding more waste production? How can other stakeholders help in promoting that as well?
9. Do you think WEEE Management also involves the promotion of alternatives that avoid EEE to become WEEE? Like the promotion of EEE repairing and the use of second-hand products. What actions do you promote with your partners?
10. Does Wecycle take into consideration the option of continuing to give ICT products a longer lifetime even when the consumer already considered it as waste?
11. Does Wecycle have some collaboration with repair and refurbish shops?
12. Although the WEEE Directive considers products reuse a priority over recycling and energy recover, these two last options are the ones mostly practised, being the only ones to have targets established by the WEEE policies. Do you agree with the prioritizing of

recycling over other forms of action (reuse, resell, refurbish) that try to preserve the use of the product in its original function?

13. What are the barriers faced by the WEEE System to incentivize ICT repairment and reuse? What are the measures Wecycle considers for incentivize the promotion of other circularity measures?

14. Are there stakeholders that should have more responsibilities and comply with rules? The producers, per example, should they have higher participation in the WEEE management process, besides paying the producers responsibility fee? And what about the costumers?

15. Do you engage with other stakeholders to know their opinions and requirements about the WEEE System?

16. How Wecycle engages with the government? Is there some kind of collaboration regarding policies creation?

17. Do you think the Dutch WEEE System efficiently addresses WEEE demands or system improvements need to be made?

18. Do you think society is making new requirements related to sustainability and circularity that the WEEE System and policies still need to comply? What are those demands?

19. In what aspects can the EPR further contribute with the promotion of the Circular Economy principles? Do you think legislation needs to be more specific about the actions that should be taken?

20. Do you think, the current WEEE System is a tool that adequately addresses the EPR demands to deal with WEEE or improvements on the system properly need to be made?

21. The policies divide the WEEE into different categories, do you think that to further implement the circularity principles different rules should be implemented for each category?

C. Nationaal WEEE Register (NWR)

Introduction:

The objective of the following questions is to understand the terms used regarding the WEEE treatment and the numbers presented at the 2018 report.

Initial check-up

✓*Confidentiality*
✓*Consent*

1. The Nationaal (W)EEE Register was created to register and report the information about the WEEE. How do you ensure the reporting provided by the producers and operators are reliable? Is there any auditing method promoted?
2. Other stakeholders like second-hand shops and refurbish stores also have a role in recyclability. Do they any obligation in reporting to you?
3. On the 2018 Report, the waste management information considered three different definitions: **complete reuse** (Compleet hergebruik), **material recycling** (Materiaalhergebruik) and **useful application** (Nuttige toepassing). What is the difference between the three definitions? What actions and treatment are considered in each one of them?
4. On the overview results, it is possible to analyse that not all WEEE collected (184.947 ton) is treated (174.947 ton). Also, from the treated part, just 95% of WEEE goes through useful application (nuttige toepassing). What is the destination of the WEEE that is collected but not treated and the remaining 5% that do not go under useful application?

D. Producer

Introduction

The objective of the following questions is to understand how producers comply with the Extended Producers Responsibility (EPR) and are involved in WEEE System. Besides, the interview aims to get opinions about the WEEE legislation efficiency and how the producers can higher contribute with the circular economy principles and promote the materials higher value retention.

Initial check-up
✓*Confidentiality*
✓*Consent*

1. How does Sony deal with the Extended Producers Responsibility (EPR) policy? What actions do you take regarding that?
2. The financial aid regarding the producer's responsibility is mandatory. Do you comply with the EPR demands as an individual producer, or are you part of a collective system?
3. How do you understand Sony's importance, as a producer, in the WEEE management system?

4. What are the most significant opportunities Sony is facing regarding the promotion of more circular products? Is the increasing popularity of concepts like sustainability and circularity, encouraging customers to demand changes in the products?
5. Regarding factors like the reduction of resources, materials scarcity and increasing waste production. Does Sony consider options to promote the extension of the products life cycle, reduce the use of materials or promote a design that facilitates specific defected parts replacement?
6. What are the main difficulties you find on developing eco-design in your ICT products?
7. What are the main barriers your company deals when trying to promote more sustainable and circular products? How has your company been overcoming these?
8. Does Sony have any initiative that encourages customers to return their old ICT? What kind of treatment do you give to the returned products?
9. When the WEEE is processed by organisations that are part of a collective system, they can collect rare and critical metals like gold, copper and platinum present in the ICT products and traded it after. Does Sony have a concern about having a priority on those metal collection?
10. ICT products are embedded in high technology. Because of this characteristics, do you think producers might have more expertise in dealing with repairing, refurbishing or recycling their own products than organisations that deal with different types of EEE (electric and electronic equipment)?
11. Do you think that, specifically for ICT, follow the WEEE policies individually is more efficient than joining a collective system?
12. Does Sony give some kind of support to repair shops like guidance/training to promote correct products repairer and selling of spare parts?
13. Do you engage with other stakeholders to know their opinions and requirements about the products you put on the market?
14. How Sony as a producer and leader on technology development deals with the trade-off of producing fast pace new technology that has as a consequence the generation of ICT products that have a short lifetime and the waste generation problem?
15. How is Sony engagement, as a producer, with the government? Is there some collaboration? Besides the obligations of EPR financial contribution and reporting requirements.
16. In your opinion, are producers having enough engagement with the WEEE System? Or do you think producers should have a higher level of responsibility?

17. Although the WEEE Directive considers equipment reuse and repair a priority over recycling and energy recover, these two last options are the ones mostly practised. Do you agree with the prioritizing of recycling over other forms of action that try to preserve the use of the product?

18. Do you think, the WEEE System adequately addresses the EPR demands on dealing with WEEE or improvements on the system need to be made?