Designing a take-back network for the e-waste from webshops' customers

The PostNL case

Master thesis

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Preface

Executive summary

Reverse logistics and extended producer responsibility are topics addressed majorly in literature in the last two decades. Additionally, more attention is given to the importance of the European WEEE directive, in order to lower the amount of e-waste being disposed of illegally and to enhance recycling programs for e-waste. Most of the research conducted so far focusses on explaining the directive and on how to implement an adequate reverse take-back network on national level in regards to the extended responsibility of the producer and importer.

Another group hardly addressed before, who are also carrying the responsibility to properly dispose of the e-waste, is the distributors of electrical and electronic equipment. In the Netherlands most retailers set up a take-back system allowing the customer to give their e-waste to the retailer when buying new equipment, mostly due to pressure from the government. However one group of retailers, the webshops, had not been addressed specifically by the government to act on their responsibility in regards to e-waste. This changed in 2012 when the Dutch government started to inspect, monitor and warn the webshops.

This research addresses the design of a take-back network for the webshops that use PostNL for the distribution of their parcels. The WEEE directive states that, the distributors have to provide their customers with a take-back opportunity at the moment of transferring the new product to the customer. This moment is for the webshops, when the driver delivers the new equipment to the customers or when a customer picks up their new equipment at a post office. Therefore, it is only logical that the logistics service provider, distributing the parcels to the webshops, plays a significant role in this take-back system. This research investigated multiple possible reverse logistics network option for the take-back service, based on literature and the input from PostNL. Through eliminations based on literature, the possibilities at PostNL, the perspectives of other important stakeholders of the service, the limitations due to legislation and finally a cost- benefit analysis, the best network solution is found.

In this research not only is the WEEE directive discussed, but also the legislation this network has to comply with in terms of operations. Additionally, the most important stakeholders were identified by means of a stakeholder analysis, and they were further investigated in regards to their points of view for such a take-back service. Moreover, the required information flows and the current financial flows are discussed, to give additional insights and to emphasize the importance of these two for the functioning of the whole network. Besides, the possible legal roles a logistics service provider could obtain in relations to handling and transporting waste is addressed. Furthermore, a recommendation is given to PostNL in regards to which roles would be the best for a logistic service provider in relation to activities of waste. In this research the possible roles found for a logistics service provider are being solely a transporter or a transporter and collector.

For the cost and benefit analysis the network options left were analysed and a comparison between two sorting facilities was made, a fulfilment company and a sheltered workplace. This led to the conclusion that the best network solution is the network where the sub-contractor driver of PostNL takes back the e-waste at the moment of delivering the new equipment from the customer and then

brings it to the closest depot. From there the e-waste is delivered to the sheltered workplace using the internal parcel distribution of PostNL. At the sheltered workplace the equipment is registered, unpacked, transported internally, sorted and tested. After that, most equipment goes to a recycler and some equipment is resold in the sheltered workplace's thrift shop. In order to comply fully with the WEEE directive, the opportunity to give back the e-waste at post offices has to co-exist next to the preferred option, since this is also a moment of transferring new equipment to the customer.

When webshops believe they are able to execute the collection for a lower cost than PostNL, they might prefer to collect themselves. In that case PostNL is only a transporter, which is also a possibility. However, in regards to economies of scale and most stakeholders requiring a high volume, a collective system coordinated by PostNL is the preferred option.

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Glossary

Activity decree (Acitviteitenbesuit): A decree which involves reporting the activities that are related to waste to the municipality where the facility is located.

AEEA: Afgedankte Elektrische en Elektronische Apparaten, the same as the English WEEE

Announcement obligation (mededelingsplicht): An obligation mandatory for every producer for who the Reea has become applicable. This group should fill in a form for the Minister stating how they will comply with the applicable articles of the directive within 13 week after they have started to conduct business that falls under the Reea

*Besluit melden en de regeling melden van afval (*reporting's resolution and reporting's regulation of waste): This resolution and regulation state how to report any activities related to waste.

Collection regulation (Inzamelaars regeling): A way of collecting waste in which one collector collects the same waste from only one address.

Driver sub-contractor: The drivers of PostNL that do not have a fixed contract, in contrast with the PostNL drivers

Dutch waste framework (Kaderrichtlijn afvalstoffen): The Dutch waste policy

EEE: Electrical and Electronic Equipment

Environmental permit (omgevingsvergunning): a permit required for all activities related to building on site, constructing buildings and all other activities that have a negative impact on the environment

E-value: The high value stream of WEEE

E-waste: The medium and low value streams of WEEE

Guidance form (begeleidingsbrief): a guidance letter which involves the necessary information flows between the receiver and disposer of e-waste at every part of the chain.

ILT: Inspection living environment and Transportation

LMA (landelijk meldpunt afval): The LMA is an organization that controls the activities that are executed in relations to waste in the Netherlands

Nationale en Internationale Wegvervoer Organisatie (NIWO): a Dutch organization that aims to enhance the proper function of the national market and cross border haulage on the road

NIWO Euro transportation permit: an operator's license for transporting companies licensed by NIWO

The NVMP: an association that manages and executes the collection and recycling system of (obsolete) electronic equipment for 1600 producers and importers in the Netherlands.

Producer responsibility: The physical, legal and economical responsibility of producers and distributors for the environmental impacts of their products throughout the products' life-cycles, including upstream impacts inherent in the selection of materials for the products, impacts from manufacturers' production process itself, and downstream impacts form the use and disposal of the products.

RBEEA (Regeling beheer elektrische en elektronische apparatuur): The Dutch directive based on the European WEEE directive

Route collection (Route inzameling): A way of collecting waste in which one collector collects the same waste from multiple addresses.

Sheltered workplace: a workplace which provides employment to people with disabilities, people re-entering the workforce and other individuals who can benefit from a protective and supportive work environment.

Spontaneous return: A return from a customer initiated at the moment of delivering a parcel, without announcing this before.

VIHB-list: A list managed by NIWO that contains all the companies that are allowed to transport, collect, trade and mediate in waste.

Waste flow number (afvalstroomnummer): a number, consisting of a part gained from the LMA and a unique part linked to the specific flow of waste.

WEEE: Waste Electrical and Electronic Equipment

1. Introduction to problem field and research question

1.1. Introduction to PostNL Parcels

PostNL originates from the first postal company in the Netherlands founded in 1799. Since 2011, PostNL N.V operates as a separate company from TNT Express N.V. PostNL is active in three different markets: mail, parcel and ecommerce and TNT express focusses on the express service. In 2012, PostNL's markets share for mail was 81%. The quality of PostNL's mail delivery is ranked as one of the highest within Europe. More than 95 per cent of all letters being sent by mail are delivered the next day. However, the numbers of letters sent is decreasing by 10 per cent annually. In order to deal with the declining volume of mail, PostNL is reducing the number of sorting locations from 260 to 125 in 2013 (PostNL, 2012).

PostNL's parcel division is currently in a growing market, due to the increase in parcels being sent related to online shopping. PostNL is the market leader in the Benelux parcel distribution market and 98 per cent of domestic parcels are delivered within 24 hours. In order to handle the major increase in the number of parcels that are delivered, PostNL is currently working on building a new logistics infrastructure. The new infrastructure consisting of 18 new sorting centres integrated in the depots together with an advanced IT system are able to process 40 per cent additional parcels (PostNL, 2012)

In terms of e-commerce, 85 per cent of the webshops in the Netherlands and Belgium are supported by PostNL. In 2011, 65 per cent of all online purchases were delivered by PostNL. PostNL offers several e-commerce services: Extra@home, premium service, shipment of special goods and return processes. The service Extra@home consists of PostNL delivering household appliances to the customer's home, installing the appliance and returning the packaging material and the old appliances from the household. Moreover, the premium service enables customers to receive goods on the next working day when ordered before 1.00 a.m. Furthermore, the service of the shipment of special goods includes goods such as wine, food and valuable shipments. Last, PostNL offers return processes such as the return of aluminium coffee cups (PostNL, 2011). PostNL aims to increase the amount and type of goods being returned by their processes, since they have the network available. Another reason to use their network to return old goods is to fulfil their CSR activities. By offering this return service PostNL helps their customers to dispose of goods at the end-of-life or end-of-use in a responsible way. Moreover, since the distributing vehicles have to drive back to the depots using diesel and emitting CO_2, it would be better if the space in the vehicles would be used to transport other goods.

Sustainability and corporate social responsibility has become an important facet of PostNL business. PostNL is a member of Green Freight Europe, an independent voluntary program established to improve the environmental performance of road freight transport in Europe (Green Freight Europe, 2013). In 2011, PostNL was the global Super sector Leader for the sector Industrial Goods & Service in Dow Jones Sustainability Indexes and in 2012 PostNL won the Lean and Green award. This award was given by Connekt to companies that want to reduce their CO_2 emissions by 20% in 5 years. PostNL wants to reduce its CO_2 emissions by 24% in 2015. The newly designed logistics infrastructure reduces the amount of kilometres drivers have to make.

Moreover, when designing the new buildings extra attention was given to applying energy efficient technologies wherever possible. Additionally, PostNL is currently looking for greener delivery possibilities for the last mile. The possibilities they are currently working on are transportation by water, by using a cargo bike or using an electric car (Keur, 2012). Furthermore, PostNL set up the Drive Me Challenge. This is a competition among delivery drivers concerning who drives the most sustainable, producing the least CO_2 and using the least fuel. This challenge creates awareness among the drivers to drive more sustainable (PostNL, 2011).

A development that affects the e-commerce market is the implementation of legislations regarding the webshops' responsibility for returning e-waste from their customers. The introduction of the EU directive2002/06/EG (WEEE directive) requires producers and importers of electrical and electronic equipment to collect and recycle the Waste of Electric and Electronic Equipment (WEEE) or also referred to as e-waste. For webshops this means that they have to offer a take-back possibility of the e-waste at the moment of transferring a new product to their customers (Europese Unie, 2003). In 2012, the Dutch Ministry of Infrastructure and Environment has been actively addressing webshops to comply with the take-back legislation; otherwise a fine would be given. In December 2012, warning letters were sent to the webshops and thorough inspections took place in the second quarter of 2013. After this inspection a second warning letter was sent to webshops, emphasizing the urge for webshops to offer a take-back solution to their customers.

PostNL decided to come up with a general solution for the return of e-waste from webshops' customers, since PostNL's delivery drivers are the parties physically present at the point of transferring the goods to the customers, as is also the case at the post offices. Moreover, PostNL possesses reverse logistic possibilities to solve the problem.

This research addresses some of the challenges PostNL still faces in terms of providing the best solution for the webshops regarding the e-waste legislations. This research focusses mainly on the PostNL Parcel division. In the rest of the document PostNL will mainly refer to the specific division of PostNL Parcels. Moreover, the term "webshops" does not refer to all webshops but solely to the ones selling electric or electronic equipment (EEE). Additionally, there are different streams of e-waste depending on their value. At PostNL the division is made between high, medium and low value e-waste. The high value e-waste is referred to as e-value and contains EEE such as tablets and smart phones. E-value is not the focus of this research. For e-value there are already multiple solutions, since money can be made with this stream. For the medium value EEE, for example desktops and flat screens and low value EEE containing a lot of plastics such as vacuum cleaners and electric toothbrushes, not many solutions are offered. As it is not clear yet how a reverse process for these streams would be profitable, the research focusses on medium and low value streams, which is referred to as e-waste.

1.2. Research question

PostNL came up with a general solution to the problem, however in order to be successfully implemented there were still some aspects that needed some attention. First of all, PostNL possessed the network to return the e-waste but it had not decided on how they should use their network and how the total take-back network needed to look like. Secondly, PostNL had not fully

answered which role PostNL should play in the return of e-waste from the webshops' customers and which roles the other players in the network should have. Moreover, factors such as different legislations, the stakeholder points of view, the financial structure and the information flows, affecting the previous two aspects needed further inspection.

This led to the following research question:

What is the optimal supply chain network, set up by PostNL in order to return e-waste from the webshops' customer, so that webshops can comply with the take-back legislation?

The research questions can be divided in the following sub-questions:

- *What role should PostNL play in the return process of e-waste from the webshops' customers and what should be the role of the other players/stakeholders?*
- *What are the possible supply chain networks that PostNL could implement for the return processes of e-waste?*
- *What is the optimal financial structure for the supply chain network?*
- *Which information flows are needed for the supply chain network in order to work well?*
- *What is the impact of legislation on the different supply chain networks?*
- *What is the influence of the stakeholders on the different supply chain network solutions?*
- *What is the best supply chain network solution for PostNL and the rest of the network based on the costs and gains?*

From these sub-questions important concepts for the research are defined. Figure 1 displays a preliminary conceptual model, covering all the important concepts and relations between the different concepts. The conceptual model is explained and discussed more in depth in chapter 3.1.

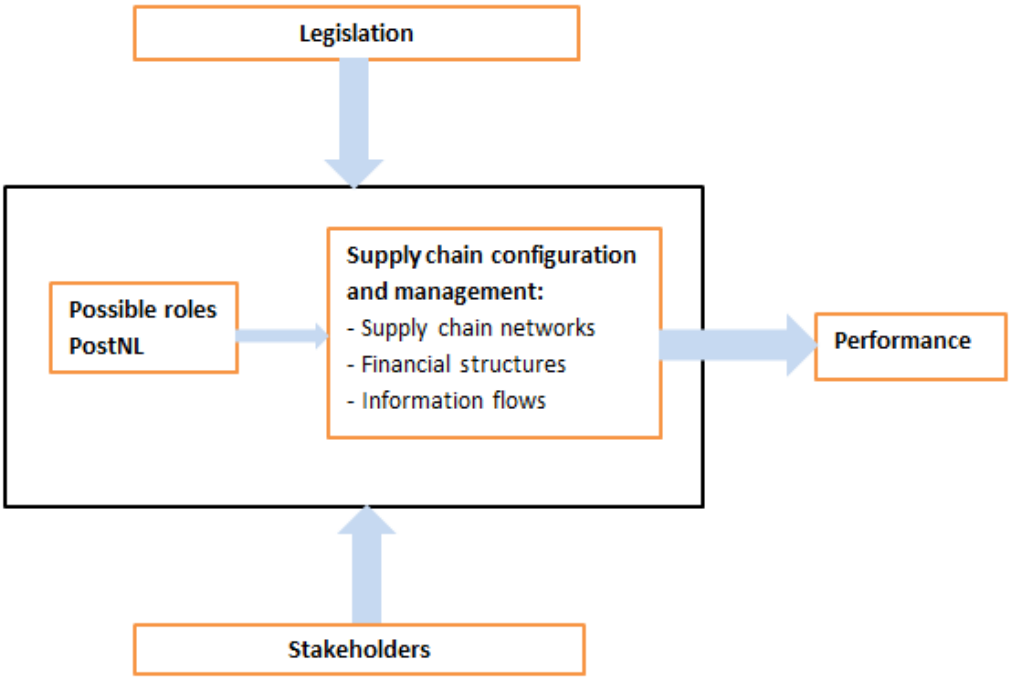

Figure 1 preliminary conceptual model

1.3. Research objective and practical/academic impact of the research

The first objective of this research is to find a return network for e-waste of webshops' customers that is feasible according to legislation and stakeholders. All the solutions that do not abide by these criteria will not help solve the research problem. The second objective is to find the most feasible network structure for PostNL. The last objective involves that the network structure should be able to be practically implemented.

The practical impact of the research is relevant for PostNL. The research gives new insights and solutions to the problems PostNL had with regards to the return process of e-waste from the webshops' customers. The aim of the research is to help PostNL successfully implement the service of returning e-waste from the webshops' customer. The success is mostly determined by whether the solution makes the webshops comply with legislation, whether the stakeholders are satisfied and whether the solution is economically feasible for PostNL.

The research also has an academic impact, since the problem of finding a solution to the return process of the e-waste from the webshops' customers is not solely a problem that is relevant for the practitioner but also for the whole industry. Since, the practitioner is a main player in the parcel delivery market, finding a solution for them is a good starting point for the whole industry. Moreover, multiple solutions are analysed in order to get the best ones, which will contribute to the knowledge and understanding of the companies and the industry. Furthermore, aspects such as legislation are analysed in detail, which clarifies how to implement these legislations into a company and what the possible implications are. Last, the stakeholders for the practitioner are almost the same or equal for the rest of the industry, so knowledge can be gained on this aspect as well.

1.4. Outline

In chapter 2 a literature review is provided, addressing all the different concepts in the conceptual model. In chapter 3 the research plan is discussed, elaborating on the conceptual model and the methodology of the research. Chapter 4 up till including chapter 8 are part of the data analysis of this research. In chapter 4 the different possible roles for PostNL are highlighted. Chapter 5 discusses briefly the influencing variables: legislation and the stakeholders. Chapter 6 is dedicated to the supply chain configuration and management. This chapter addresses all the different possible network structures found and discusses the financial structure and the information flows. Chapter 7 regards a more extensive analysis of the legislation and stakeholder which upon some networks are also eliminated. The last chapter of the data analysis is chapter 8, which concerns the performance chapter of the research where the network structures are evaluated and eliminated based on costs and gains. Chapter 9 wraps up with concluding comments, describes the limitation of the research and provides possible opportunities for future research

2. Literature review

This review evaluates the existing literature on e-waste with specific focus on reverse logistics management. Its structure and form are inspired by the problems that PostNL is currently facing and the conceptual model mentioned in section 1.2.

2.1. E-waste

Over the past ten years the number and diversity of electronic equipment in households have increased majorly. Also the customers have become more demanding in terms of having the newest technology. This fastens the clock speed of the introduction of new technology in the electronic sector. The frequent introduction of electronics goes hand in hand with an increase in obsolescence of the old products, therewith increasing the amount of e-waste (Janse, Schuur, & de Brito, 2010).

In literature the definition of e-waste constructed in the EU WEEE Directive is mostly used: "Electrical or electronic equipment which is waste including all components, sub-assemblies and consumables, which are part of the product at the time of discarding" (European Commission, 2002). Directive 75/442/EEC, Article 1(a) "defines waste as any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force" (European Commission, 2002). However, Kahhat, Kima, Xua, Allenbya, andZhang (2008) argue that calling it waste can be misleading, since a significant amount of e-waste will be used for the secondary market and therefore should not be entirely considered as waste. E-waste consists of amounts of valuable materials and especially precious metals. Hence, recovering valuable materials from e-waste such as gold and copper could lead to profitable business opportunities (Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmannc, & Boni, 2005).

Moreover, it is important to control e-waste when it is being disposed of or recycled, since e-waste consists of more than 1000 different substances, most of them being toxic. In the US 40% of lead in landfills used to be caused by electronic consumer waste. The toxins can have serious negative impacts on the environment and human health, potentially causing brain damage, allergic reaction and cancer (Puckett & Smith, 2002).

2.2. Reverse logistics supply chain network

In the literature reverse logistics has become more and more important. Broadly speaking, reverse logistics is driven by factors such as environmental legislations, extended producer responsibility (EPR) economics and improved customer service (Lau & Wang, 2009). For an overview of the basic activities and flows in reverse logistics refer to Srivastava (2008) and for a more quantitative side of reverse logistics consult Fleischmann, Bloemhof-Ruwaard, Dekker, Laan,van Nunen & Van Wassenhove (1997). Designing a fitted reverse logistics network involves many decisions that need to be made. Each return needs a different kind of reverse logistics supply chain in order to optimize value recovery, making the reverse logistics supply chain complex (Guide, Harrison, & Van Wassenhove, 2003).

First of all, different sort of networks for different levels of value recovery are used. Moreover, for designing the processes there is a distinction between reverse logistics being executed by OEMs or by third party logistics service providers. Furthermore, decisions must be made concerning the

collection and acquisition of the products. Can distribution and collection be combined or is it better to use drop off points to acquire the products? This links to the discussion whether the most effective design is integrating the reverse logistics in the forwards supply chain or whether it is optimal to have a dedicated reverse logistic supply chain (Fleischmann, 2001). Wehkamp is an example of a webshop that integrates the pick-up of the products from customers in the forward supply chain. Wehkamp's transporter schedules the pick-up on a delivery route in the customer's area. If there is no suitable route available, the pick-up will be delayed. The customer can then decide to bring it to the closest post office. Mostly, the pick-ups are realized within 24 hours after the return request by the customer (De Koster & Zuidema, 2005).

Additionally, an issue often mentioned is whether the testing and grading of the goods should be centralized or decentralized. Centralization increases the required transportation to the sorting and grading facilities. Transportation over long distances may be restricted by legislation, when this involves crossing borders. Moreover, the separation of material that should be disposed of right away is being postponed to a sorting and grading facility, increasing the transportation cost. On the other hand, less expensive test equipment and skilled labour are needed. For decentralization this is the opposite, less transportation cost to the testing and grading facilities and more test equipment and skilled labour are needed (Fleischmann M. , 2001). De Brito & Dekker (2003) made a framework that helps analysing issues that might arise in regards to reverse logistics. It is based on the following aspects: the driving forces and return reasons, what type of products are streaming back, how they are being recovered, and who is executing and managing the various operations.

2.3. Roles of the logistics service provider

One of the aspects in the Brito and Dekker (2003) framework is who is managing and executing the activities in the reverse logistics network. This is important for the understanding of the reverse logistics network, since multiple activities can be executed by several actors. For this research the practitioner is a logistic service provider, therefore the role of the logistic service provider in reverse logistics is emphasized. Mostly, in reverse logistics the collection process is outsourced to a third party logistics provider. Third party logistics providers can take advantages of economies of scale and can pool shipping and facilities needs for several customers. Hence, this basically involves the transportation from the customer to the customers' reverse logistics facility (Barker & Zabinsky, 2008).

The Wehkamp case is a good example, of the logistic service provider being solely a transporter. The goods return via the regional depots and the DCs of the transporter to the DC of Wehkamp. The sorting and testing is only done at the Wehkamp's DC's. The logistic service provider solely uses its network for transportation of the goods (De Koster & Zuidema, 2005). This is the same for end-of life large white goods in the Netherlands. The carrier returns the old product from the end-customer to the DC of the retailer or a retailer transhipment station, if he does not have his own DC. Then the sorting is done at the retailer's DC or at the retailer transhipment station. From those two facilities selected carriers by the NVMP transport the goods in bulk to a predetermined processor (de Koster, Flapper, Krikke, & Vermeulen, 2005). The NVMP is an association that manages and

executes the collection and recycling system of (obsolete) electronic equipment for 1600 producers and importers in the Netherlands.

Krumwiede & Sheu (2002) identify the importance of transportation in all aspects of reverse logistics, since manufacturers mostly do not want to be the end destination of returned goods. Manufacturers prefer to have an outside source or a third party logistic provider dispose of the goods, leading to transportation companies that are left holding the goods waiting for disposition information. In this case the logistics service provider is not only returning the goods from the customer back to the DC but also the party disposing of the goods.

2.4. Stakeholders/players in the reverse logistics supply chains

In the previous section the possible roles of a logistic service provider are discussed. For the design of the reverse logistics network identification of the other stakeholders is also important. This part of the literature review sums up several articles identifying different stakeholders. These stakeholders are used as an input for the stakeholder analysis and the reverse logistics network.

A distinction can be made between three categories in regards to the actors: forward supply chain actors (suppliers, manufacturer, wholesaler and retailer), specialized reverse chain players (jobbers, recycling specialists, etc.) and opportunistic players (charity organizations etc.) (de Brito & Dekker, 2003). A small overview of the most important players mentioned in several articles is provided. De Koster et al. (2005) mentions retailers, municipalities, NVMP, regional transhipment stations, processors, the carriers and the owners of the goods at the starting point of the collection process. Janse et al (2010) identified four main actors for reverse logistics supply chains: producers, retailers, logistics service providers and service and repair companies. Lau & Wang (2009) focusses more on stakeholders related to reverse logistics: suppliers, government, lobbying groups, buyers and competitors. In the plastic recycling industry the following players are included: municipalities, joint ventures, material recovery facilities, brokers, intermediate processors, and end users (Pohlen & Farris, 1992). These players are all considered as stakeholders in this research, most of them are therefore analysed in the stakeholder analysis of chapter 5.

2.5. Legislations

The legislation mentioned the most in literature with regards to e-waste are the WEEE directive, the RoHS directive and the Basel Convention. The RoHS directive restricts the use of six hazardous compounds: lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls (PBB), and polybrominated diphenyl ethers (PBDE) that were regularly found in EEE (European Commision-RoHS Directive, 2003).

Under the WEEE directive 25 member states of the European Union adopted regulations related to e-waste. The regulations were related to five main categories: (1) EEE product design, (2) e-waste collection, (3) e-waste recovery, (4) e-waste treatment and treatment financing and (5) EEE user awareness. The main goal of the directive is to recover, recycle and reuse more e-waste (European Commission-WEEE Directive, 2003). For producers and importers the introduction of the EU directive2002/06/EG (WEEE directive) requires them to collect and recycle the Waste of electric and electronic equipment (WEEE). In the Netherlands this directive is implemented under “Het

besluit en regeling elektische en electronische apparatuur (BREEA)". This directive states that producers and importers are responsible for the collection, transportation and processing of e-waste (Europese Unie, 2003). A producer and importer bearing the responsibility over their obsolete products connects to a research area, which has been researched more extensively in the past years, namely the extended producer responsibility. A widely used definition of the extended producer responsibility is as follows: "*The concept that manufacturers and importers of products bear a degree of responsibility for the environmental impacts of their products throughout the products' life-cycles, including upstream impacts inherent in the selection of materials for the products, impacts from manufacturers' production process itself, and downstream impacts form the use and disposal of the products. Producers accept their responsibility when they design their products to minimize the lifecycle environmental impacts and when they accept legal, physical or economic responsibility for the environmental impacts that cannot be eliminated by design*" (Davis, 1994).

The WEEE directive also identifies a responsibility for the distributor of the products. Article 4 of the BREEA describes one of these responsibilities, which is that if the new equipment is from the same type as the discarded electronic or electric equipment, the distributor ought to collect it from private households (VROM, 2004). For retailers and webshops this means that they have to offer a possibility to their end-customer to hand in their e-waste, at the selling point of the new equipment. For brick and mortar stores this implies that customers should be able to hand in their e-waste at the shops. In case of webshops, they should provide the customer with the possibility to hand in their e-waste at the moment that the product is being transferred to the customer.

The Basel convention under the control of Transboundary Movements of Hazardous Wastes and their Disposal was established in 1989 under the United Nations Environment Program and it came into force in 1992, due to the growing amount of international trafficking of hazardous wastes (Kummer, 1992). The goal of the convention is to regulate the movement of hazardous waste, including WEEE between countries (Nnoroma & Osibanjo, 2008).

2.6. Financial structure

An option to finance the collection and reprocessing of e-waste is to make manufacturers operational and financial responsible for the collection and disposal of e-waste (Kahhat, et al., 2008). In Europe several cost structures to finance the reprocessing and collection of e-waste are used. The first model is the *compliance costs model*. By using this model the producer finances the management of historical and new WEEE. A product falls under the new WEEE when being produced after 13th of August 2005, the rest is considered historical. The financing can be done by setting up their own take back system or by joining a compliance scheme. The second model is the *Compliance cost and visible fee* model. This system is the same as the compliance cost model only for the historical WEEE a visible fee is used to get money back from the end user. The third model is the *Reimbursed compliance cost* model. This model is almost the same as the second one the only difference is that the visible fee to get money back from the final user is also used for new WEEE. The last model is a model that uses the *recycling fee*. This structure is without the involvement of the producer. The final users bear the cost for the WEEE when buying a new product (Magalini & Huisman, 2007).

In the Netherlands the reverse logistics and disposal of end-of-life goods white goods are funded by a fee paid to the NVMP by the producers. From this fund the NVMP pays the actors in the reverse supply chain (De Koster et al., 2005).

In Japan the recycling fee and additional fee to cover the transportation of the e-waste has to be paid by the consumers. At the same time the system forces retailer to collect obsolete products from consumers. For PCs compulsory recycling came into force. For products sold before October 2003 a recycling and collection fee is still being charged to the customer. For products produced after October 2003 manufactures grouped in the PC3R Promotion Centre are responsible for collection and recycling/reuse of computers. For these products an invisible non-refundable fee is included in the sales price of the products (Kahhat, et al., 2008).

In South-Korea manufacturers, distributors and importers have to set up an account to deposit recycling funds, being refundable related to the actual volumes of waste recycled. These goals may be either met by outsourcing their waste recycling activities or by doing it themselves. Retailers and supplier are also forced to collect and transport used products for free when buying a new similar product. When the customer does not buy a new product, the customer has to pay a collection fee to the government. However, the manufacturer is responsible in enforcing the recycling and collection fee from the customer (Yoon & Jang, 2006).

2.7. Information flows

A major hurdle in efficient product recovery decisions is the loss of information regarding the status of the product after the point-of-sale (Parlikad & McFarlane, 2007). It is therefore important to have information on the product stage and past usage in order to decide on the destination of the electronic equipment after its end-of-use or end-of-life (Janse et al., 2010). When this information is absent there will be a high level of uncertainty in deciding the destiny of a product at the end-of-life, also caused by the major homogeneity of the products (Yang, et al., 2007).

Additionally, it is important to attain information regarding the amount of obsolescent electronic equipment, in order to attain an indication in regards to how much e-waste there is. There are several methods mentioned in the article to estimate the quantities of WEEE. *The consumption and use method* is used in the Netherlands to estimate the potential amount of WEEE. This method takes the average amount of electrical and electronic equipment of a typical household as the basis for their estimation of WEEE. In Germany the market *supply method* is used, which bases their prediction on production and sales figures in geographical regions. In Switzerland they assume that private households are currently saturated in regards to electronic equipment, meaning that they believe that for every new equipment an old one is at it end-of-use or end-of-life (Widmer et al., 2005).

From the end-of-life large white goods case (De Koster et al, 2005) could be learnt what kind of information is needed in order to pay the different parties in the reverse supply chain. Also insights in information flows between different actors within the reverse logistics chain could be attained. Data must be tracked in regards to when and which quantities of what are transferred to NVMP by the different collectors, when and which quantities of what are transported from where to where by

the two selected third party logistics service providers, when and which quantities of what are processed by the processors and which quantities are sold to whom and actually disposed. Other data needed concerns the amount of disposal fees paid by the buyers of new products and data regarding the planning of the collection and processing of carriers and processors (De Koster et al., 2005).

Also under the WEEE Directive information is more important in the reverse logistics of waste. The 2008/98/EG directive article 23.1 states that for hazardous waste producers and collectors and transporters should keep a chronological ledger containing specific information of the waste. For example, the amount, origin, destination and collection frequency should be registered (Europese Unie, 2008).

2.8. Performance

Many articles identify the economic aspect as being an important performance factor for return logistics. Ravi, Shankar, & Tiwari (2005) displays economics as the driving force for reverse logistics concerning the different recovery options. A company could receive direct and indirect economic benefits. Guide, Neeraj, Newman, & Van Wassenhove (2005) describe the ReCellular case, a company that refurbishes cell phones, who achieves economic advantages by doing this. On the other hand it is difficult to identify the actual cost of reverse logistics but failing to do so means that return logistics need to be reassessed, since this can also be a hidden factor reducing the profits (Dawe, 1995; Schwartz, 2000). These economic aspects are often used as a performance measure (Lambert, Riopel, & Abdul-Kader, 2011).

Giuntini & Andel (1995) state that in reversed logistics the cost are related to acquisition, warehousing, and material resources. However, to be able to understand the economic aspect a more extensive overview of cost in reverse logistics follows. The first cost in reverse logistics is related to the stage when a customer expresses the need to return a product. Here it needs to be identified, for example which products can be returned. The cost involved to do this are personnel cost, office automation and office space. These costs depend on the amount of returns and the desired service level. Second is the collection of the returned product. The cost related to this are the transportation cost and the cost concerning a consolidation space. The exact cost depends on the volume of the returned products using the transportation mode. For the sorting process the cost relates to: receiving of the product, personnel of the sorting facility and the costs for the different handling methods. These are variable depending on the volume of returned products. After sorting comes the last phase: processing and treatment. The cost comprises of cost for working space, warehouse space, spare parts, equipment, personnel and a major amount relating to transportation, since the returned products have to be transported somewhere again. This phase also has a revenue aspect. Since, in this phase the aim is to recover as much value from the products as possible (Lambert, Riopel, & Abdul-Kader, 2011).

From the plastic recycling industry could also be learnt that mostly the biggest cost in reverse logistics is the transportation cost. This is caused by the low density of the return products that make the transportation extremely expensive (Pohlen & Farris, 1992).

This literature review has provided information about all the relevant concepts as displayed in the conceptual model. Based on this literature review the conceptual model is filled in more detail in section 3.1. Moreover, this literature is used as input in the analyses in later chapters.

3. Research plan

3.1. Conceptual model

This section explains and elaborates on the conceptual model displayed in section 1.2. The literature review in chapter 2 provides some useful information for every concept, enabling to define the different concept in more detail for this particular research.

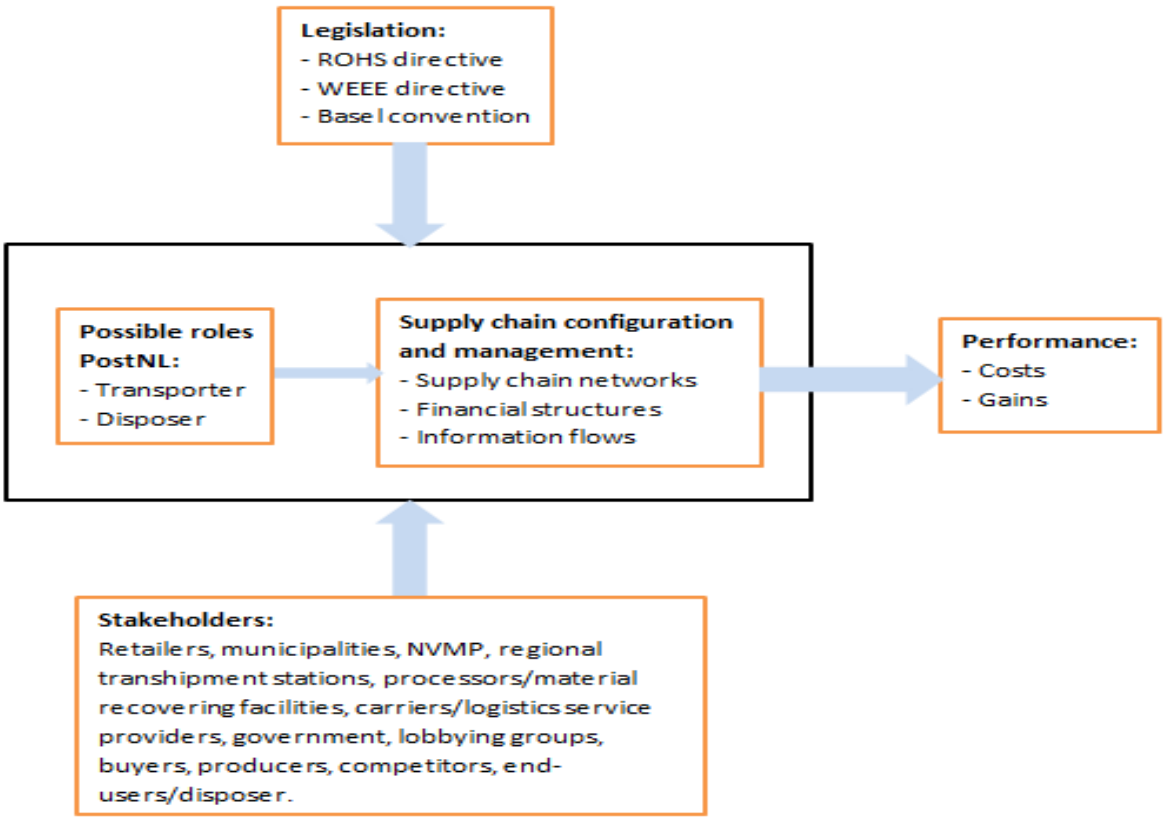

Figure 2 Detailed conceptual model

3.1.1. Possible roles of PostNL

This concept covers the different roles PostNL could have concerning the return process of e-waste from webshops' customers. For example, is PostNL only a transporter or also a disposer of e-waste? This is the starting point, since the research is done with a focus on practitioner. The different roles of the practitioner could lead to different supply chain configurations. From the literature two roles for logistics service providers were derived. The first role is being a transporter of e-waste in the reverse logistics supply chain network. The second role is being a disposer of e-waste. When being a disposer the logistics service provider is mostly also the transporter.

3.1.2. Supply chain configuration and management

Supply chain configuration and management of the reverse logistic processes of e-waste from the webshops' customer is the main part of the research. The focus is more on the configuration of the supply chain rather than the management of the supply chain, since the research focusses mostly on the different possible structures. However, when constructing a supply chain configuration the management of a supply chain should be acknowledged as an aspect, since this involves the practical implications of the different configurations.

First, the different roles of PostNL lead to different supply chain networks. Based on whether PostNL is for example a transporter or a disposer there are different players in the reversed logistic process, leading to different reverse logistics supply chain networks. Second, for the different supply chain networks, a financial structure needs to be found. Last, the information flows needed within the reversed supply chain networks has to be identified. For these three sub-concepts the literature provides some insights and background information addressing different possible network and financial structures and it also mentions some information that is needed in a reverse logistics supply chain.

3.1.3. Legislation

Legislation and stakeholders are the main influencing variables of the conceptual model. Legislation influences the different possible roles of PostNL and the different aspects of the supply chain management. First, legislation affects the different roles PostNL is allowed to execute and therewith it influences the supply chain management. Also, whether the different solutions are possible are partly determined by the legislations. For this research the most important legislation according to literature are the RoHS directive, the WEEE directive and the Basel convention.

3.1.4. Stakeholders

The stakeholders are a key aspect in determining network structures. The following stakeholders are mentioned: Retailers, municipalities, NVMP, regional transhipment stations, processors/material recovering facilities, carriers/logistics service providers, government, lobbying groups, buyers, producers, competitors, end-users/disposer.

3.1.5. Performance

The concept of "Performance" evaluates the solutions based on the economic viability of the different networks. In the literature often the economic factors are used to determine the performance of the reverse logistic network solutions. The economic factors are divided into costs and gains.

3.2. Methodology

3.2.1. General description of the methodology

This research is a practice oriented case study. The case study research strategy is applicable, since this method is used to analyse and solve practical business problems. The objective of the case study is design-oriented, since the goal is to design a solution for PostNL. For this research the current situation of PostNL's activities regarding the return process of e-waste from the webshops's customer was assessed. Based on this analysis, some key problems were identified aiming to be solved during this research. The researcher took a consultant role throughout the project. In order to answer the research question, some required empirical data was collected based on the conceptual model throughout the research. The data used consists of a combination of primary and secondary sources. In order to conduct a thorough and deliberate research, different kinds of sources were used. The different concepts are briefly discussed in the steps below, in terms of how the concepts have been analysed and researched and where the information has been obtained from. A table in **Appendix A** displays an overview of where the data per concept was taken from. In order to

structure the research, 5 steps were identified. A small summary of the steps is also provided in figure 3.

3.2.2. Step 1

The first step of the research was to identify the different possible roles PostNL can have within the return process of the e-waste from webshops' customers. This was the starting step since the research was written from the perspective of PostNL, a logistics service provider. These different roles were the input for the supply chain configuration and management concept. The overview of the different roles and what they involve were gained from the VIHB registration list, since this contains options of licensed roles an actor can have in regards to waste transportation and collection. Therefore, first the VIHB-list was explained, followed by an analysis of which roles PostNL could possibly execute. The VIHB-list is a list managed by NIWO, an organization assuring the proper function of the transportation in the Netherlands, which contains all the companies that are allowed to transport, collect, trade and mediate in waste. The information about the VIHB list was gathered from the website of NIWO. Some questions have been asked to one of the employees of NIWO over the phone.

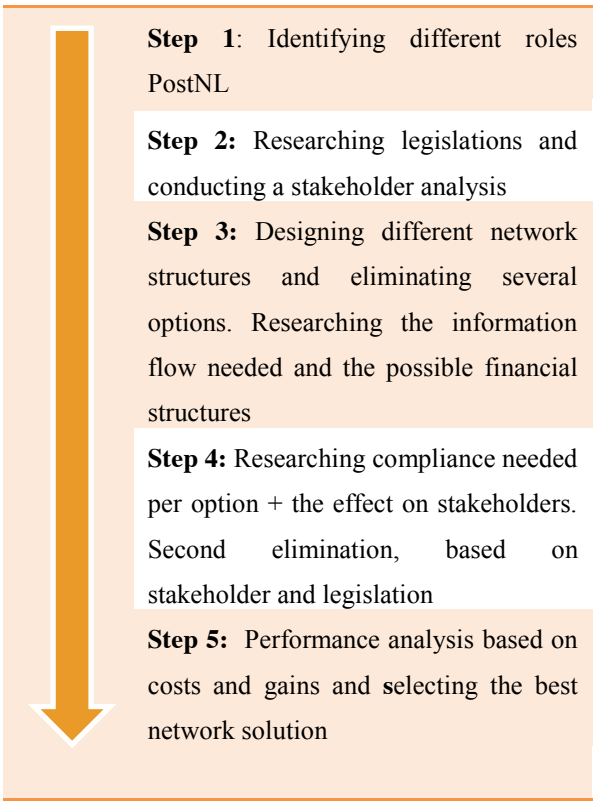

Figure 3 Overview of the steps of the research

3.2.3. Step 2

In this step, a basic understanding of the legislations influencing the reverse logistics network of e-waste was gathered from academic literature and from internal information of PostNL. This legislation overview explains the WEEE directive and the relevance for this network extensively. However, other legislation in regards to the transportation and storing of waste are briefly mentioned. These are addressed in a later step also explaining the effect in practice. Further, a stakeholder analysis was conducted in this step, since it provides an understanding of all the different players involved in the reverse logistic processes, which were useful when designing the reverse logistics network. For the analysis the stakeholder analysis model of Johnson & Scholes (1993) was used, classifying the stakeholders based on the interest in the network set up for the new service and their influence on the new network. The stakeholder analysis was split into an internal and external stakeholder analysis, since PostNL cannot be seen as one stakeholder due to the size of the organization and the different interests. The stakeholders were obtained from meetings with employees of PostNL and the literature regarding stakeholders in a reversed logistic network.

3.2.4. Step 3

The input of the first and second step led to the third step, which is dedicated to the supply chain configuration and management and especially involves all the different possible network structures. This step is important for the research, since here the different possible networks are constructed. The options for the different network structures were gathered from literature, but also from interviews and or meetings with PostNL.

The main difference between meetings and interviews is that interviews were conducted one on one and mainly focused on the information needed, determined before the interview. The meetings on the other hand involved more people and touched upon more topics than was usually relevant for the research. However, the procedure for interviews and meetings was the same. The interviews and meetings were not recorded, but notes were taken. The interviews and meetings were not recorded, since in this case people were more willing to cooperate. In order to prevent data loss the notes were always transferred into a small written report, right after the meeting or interview took place. Moreover, the reports were classified per concept of the conceptual model and relevant data was copied to the different word document dedicated to a concept in order to keep an overview of all the gathered information. This protocol was followed for all meetings and interviews that were held or conducted with the purpose of gathering information for the research. The meetings are not added to this research in the appendix, since they are only allowed to be visible within the corporation. In the citation in the text, meetings and interviews are referenced as personal communication, and are therefore not part of the bibliography.

All the different networks go through pre-determined evaluation stages and elimination points, inspired by the stage-gate model of Cooper (2008) (see figure 4). The stage-gate model is a method in which projects are evaluated during the stages and then a go or kill decision in regards to the projects is made at the gates. In this analysis, the method is applied to different network structures instead of projects. The first stage and gate are in the third step. At that gate the elimination takes place based on literature and the limitations addressed by the internal stakeholders of PostNL. At the end of the next stage, the networks are killed at the gates based on whether the networks are possible due to legislation. If all are possible, preference is given to the networks where less impact of the legislation is felt on the operations. Then, some networks are evaluated and eliminated based on the stakeholder analysis. Finally, the last evaluation and elimination takes place in regards to a cost-benefit analysis.

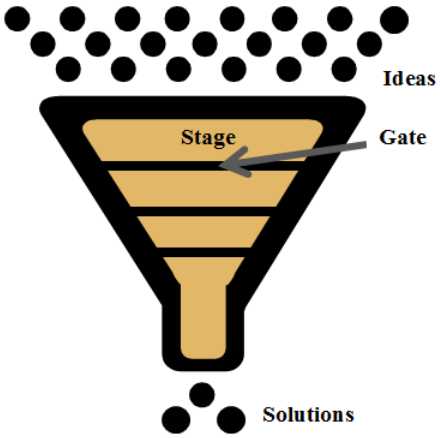

Figure 4 Adapted stage-gate model

Moreover, the rest of the supply chain configurations and management concept were researched. The financial structure was based on financial systems addressed in the literature, but also the limitation and preferences suggested in the legislation and stakeholder sections, which were also gathered from meetings with stakeholders. Additional, information was obtained from other non-

academic online sources. The financial structure section does not include the thorough calculation of the cost per network options, but explains the possible structures of who is financing the different part of the reverse logistics processes. The information flows are based on the literature, information from PostNL and data gathered from the meetings with the stakeholders. A general overview is given regarding the information flows.

3.2.5. Step 4

In this step a more thorough analysis was conducted regarding the legislations PostNL needs to comply with when implementing the different options. The information was gathered in the same manner as described in step 2. Only extra information was gathered from the landelijk meldpunt afval (LMA). The LMA is the organization that controls the activities that are executed in relations to waste. Other information was gathered from an employee from the permit department of the province of Noord-Holland, who advises on for which activities a permit is needed.

Regarding stakeholders, most information was gathered as described from the stakeholder analysis. However, some additional sources were used. The information with regards to the customer was gathered from a survey conducted by an intern at PostNL. This survey investigates the willingness of customers to give back their old equipment to a driver of PostNL when a new product is being delivered. As stated in the survey under the described program, an end user needs to provide the old equipment with packaging and a reply mail number with an address as stated on the website.

For the other sources extra information was gathered mostly form meetings and interviews. Meetings with the project manager of the e-waste proposition were held to gather data about the points of view of the webshops. Further, multiple days were spent at the depot and a day with a driver to gather insights from these stakeholders. Also, with two recyclers and two sorting centres meetings were held to understand their points of view. For the perspective of the government more secondary sources were used, recently published by advisory bodies.

Also, a competitor analysis was conducted in order to get some extra insights in possible solutions for designing a network for this service. For the competitor analysis, first the major players in the parcel and express market were identified based on the market shares. These were investigated on whether they offered any return possibilities for the e-waste of webshops customers. This was done by exploring their websites. This method turned out to be not sufficient and therefore a new approach was sought which involved analysing the websites of webshops in regards to whether they offer a new for old take-back of e-waste from their customers. A list from webshops registered on thuiswinkel.org was derived. Thuiswinkel.org is an association guarding the interest of webshops. In total the list of electronica webshops consisted of 207 Webshops. All the webshops sending their parcel with one of PostNL's competitors were analysed in regards to whether they offer a take-back solution or not.

At the end of the stakeholders and legislation analyses, conclusions were drawn in regards to the preferred network.

3.2.6. Step 5

The last step regards the performance measurement, based on the cost and benefits of the different networks left after the previous evaluations and eliminations.

For these networks, the cost for different volumes of the parcels was calculated, since the costs consist of fixed and variable costs. The different volumes were expressed in weeks. The volumes used for the cost calculations were as follows: 1, 5, 10, 20, 50 or 100 parcels per week. This might not seem high but the current volume is between 1 and 5 parcels per week. Therefore, a volume of 100 is already a major increase.

The costs that were calculated for the different networks were clustered in groups. In this chapter the different kinds of cost are addressed, together with the source of the costs. In the chapter dedicated to the performance of the networks, the calculations are further explained and a cost analysis follows.

The first cluster is the cost made when transporting the parcel with PostNL's parcel distribution. First of all, this consists of the cost related to bringing the parcel of e-waste from the customer to the closest depot or the cost incurred from bringing a parcel from a post office to the closest depot. Secondly, the cost made when bringing the parcel of e-waste from the first depot to the depot closest to the delivery address. This cost includes all the costs made per parcel at the depots, including depreciation and administration cost and the transportation between the depots. The last cost concerns the cost to deliver the parcel from the depot to the delivery address. All these costs were gathered from the Control department of PostNL after having several meetings and phone conversations in regards to which costs were needed.

The second cluster contains all the cost made at the sorting centre. These involve the costs that are the same for all the options such as unpacking the parcel, registration of the e-waste, internal transportation and handling of the parcels and the storage of the parcels of e-waste. Depending on which facility is used and whether the additional gains of the activities offset the extra cost, the parcel could also be sorted and tested in order to see whether the e-waste is resalable. Sorting could be done based on whether the equipment could be reused or not. Another way to sort the e-waste is by making a division per product group for the receiving recycler. The testing is done by executing a plug test to see whether the product still works or not. These costs are all variable costs and are linked to the amount of minutes spent on executing the different handlings per parcel. The level of the cost is determined by the hourly wage of an employee at the sorting facility. A fixed cost of the sorting centre is the storage costs which is calculated in pallet places per week. Two different sorting centres were assessed, a sheltered workplace and a fulfilment company.

Since there was no data yet about the time spent per activity per parcel; a pilot was run at the sheltered workplace. The amount of parcels received so far at the sheltered workplace was used for the pilot. All the handlings mentioned before in regards to the sorting facility were timed, so the costs of the different activities could be calculated. A part of the registration and handling of e-waste is weighing the kilos of e-waste and carton. From the total amount of kilos an average could be calculated, which is useful for the further calculations. The minutes spent per activity from the

pilot of the sheltered workplace are also used for the calculations at the fulfilment company. The actual wage per employee and storage cost were gathered from the sheltered workplace and the fulfilment company.

A further cost incurred at all the different networks is the cost accounted per kilo e-waste to transport the e-waste to a recycler. This cost is a fixed fee per ton of e-waste, charged by the recyclers. Some recyclers also account for this cost in the fee they are willing to pay for the e-waste. This cost was given by one of the recyclers

The last cluster describes the potential gains. This consists of the amount that could be attained from the carton from the boxes, from the e-waste, which depends on the activities executed at the sorting centre, and from the probable gains from resalable equipment. The gains from the e-waste are prices set for the e-waste by two recyclers and a price from one of the partners of the sheltered workplace. The average of the three amounts was taken in order to get a more representative number. The price for the sorted e-waste was based on the same. The gain from the resalable equipment was based on the information gathered from the sheltered workplace. The employees at the sheltered workplace are knowledgeable about what equipment is worth second hand, since the sheltered workplace also possesses a thrift shop.

4. Possible roles for PostNL

The different possible roles PostNL can have, are important for the later chapters since this influence the supply chain configuration and management. The roles PostNL can execute with regards to waste transportation are based on the Dutch "Wet Milieubeheer", a Dutch Environmental management law. Article 10.37 of this law prohibits companies to transfer their waste or dangerous waste to another party. Exceptions exists when the receiver of the waste is authorized and in possession of a licence and or is listed on the VIHB list (Stichting vervoeradres, 2012). PostNL is listed on the VIHB list and is therefore allowed to receive waste. The VIHB list stands for: Vervoerder (transporter), Inzamelaar (collector), Handelaar (trader) and Bemiddelaar (mediator). These are the four possible licensed roles identified in regards to transferring waste by the "Nationale en Internationale Wegvervoer Organisatie (NIWO), a Dutch organization that aims to enhance the proper function of the national market and cross border haulage on the road (NIWO, 2012). The activities mentioned on the VIHB-list were analysed as possible roles for PostNL. The VIHB-list is more extensive than the roles found in the literature review. The only roles found in the literature review in regards to logistics companies are: being solely a transporter or being a transporter and/or a disposer of waste.

4.1. Explanation of the VIHB-list

In order to be allowed on the VIHB-list companies have to show their reliability for all the four roles. This is mainly done by an official statement regarding the behaviour of the companies (Verklaring omtrent gedrag), a copy of a transportation license and an extract from the chamber of commerce. Companies have to attain a professionalism certificate when solely being a trader or mediator. However, in combination with also being a transporter or collector this certificate is not required (NIWO, 2012).

An applicant for the list has to apply for the exact activities/roles it wants to execute, since they are exclusively authorized to execute the activities for which they are registered on the VIHB-list. Any combination of the activities is allowed. A collector of waste is according to the law always a transporter but the reversed is not the case. PostNL is currently registered as a transporter on the VIHB-list (NIWO, 2012). A short explanation of the four roles follows below.

4.1.1. Transporter

The transporter of waste is the party that solely transports the waste from a disposer to the receiver of the waste. Being a transporter involves transporting the waste of the disposer to another location for a fee. The transporter does not have the legal ownership of the waste and cannot decide to which processor or party it transports the waste to (Landelijk afvalbeheerplan, 2010).

4.1.2. Collector

In the new Dutch waste framework (Kaderrichtlijn afvalstoffen), the following definitions is incorporated regarding what is considered as collecting waste: "The collection of waste including the preliminary sorting and preliminary storage of waste for the purpose of transporting it to a waste treatment plant" (Landelijk afvalbeheerplan, 2010). When parties agreed that the legal ownership of the waste transfers from the disposer to the receiver at the actual disposal moment, the receiving

party is the collector. The collector of e-waste, is therefore also a coordinator of the network in terms of where the e-waste is transported to and where it might be sorted and stored. The transporter solely executes the transportation.

4.1.3. Trader

A trader is a natural or legal person who buys waste with the aim to sell it to another party. At some point in time the trader has the legal ownership of the waste. Due to its role a trader cannot have the physical possession of waste generated by another party. A trader is not a party to who waste is allowed to be transferred based on article 10.37 paragraph two of the Wet Milieubeheer (Landelijk afvalbeheerplan, 2010).

4.1.4. Mediator

A mediator makes arrangements for the management of other people's waste. He shall make arrangements to ensure that waste is transferred from a disposer to a processor. Mediation occurs in commission of either the processor or the disposer of waste. When mediating, the mediator does not have the legal ownership of the waste, but makes arrangements on behalf of a third party. Neither has a mediator the physical possession of the waste, since it may not be transferred to him (Landelijk afvalbeheerplan, 2010).

4.1.5. Possible roles for PostNL

	Transporter	Collector	Trader	Mediator
Physical possession	Y	Y	N	N
Legal ownership	N	Y	Y	N

Table 1 Overview physical possession and legal ownership for the different roles

Table 1 provides an overview of whether a role incurs the physical possession and legal ownership of the waste. Since trader and mediator do not involve having the physical possession of the waste, PostNL cannot perform these activities for the same waste they are transporting and or collecting. Therefore, it is not possible for PostNL to either be a trader nor be a mediator unless they execute these activities for other streams of waste. Since PostNL is a logistics service provider and transporting waste is only a very minor part of the business this is not their ambition. This results in only two likely roles, being solely a transporter or being a transporter and a collector. These two different roles are the main input when designing the different networks structures and the later analyses also make a distinction between these two roles.

5. The influencing variables

5.1. Stakeholders

The analysis is focused on the different stakeholders PostNL has to cooperate with, in terms of the activities of the e-waste reverse logistics network. For other activities, the stakeholders can be different. The analysis involves two variables: the influence and the interest of the stakeholder in the new service, which is based on a well-known model by Johnson & Scholes (1993). It is divided into an internal and an external stakeholder analysis. An explanation reasoning the position of the stakeholders in the stakeholder analysis matrix is provided below.

5.1.1. Internal stakeholder analysis

The internal stakeholders are chosen based on several meetings and conversations the researcher had with the project manager of the e-waste proposition and with the process design and network design departments, all within the company. Figure 5 gives an overview of the internal stakeholders and their position with regards to influence and interest.

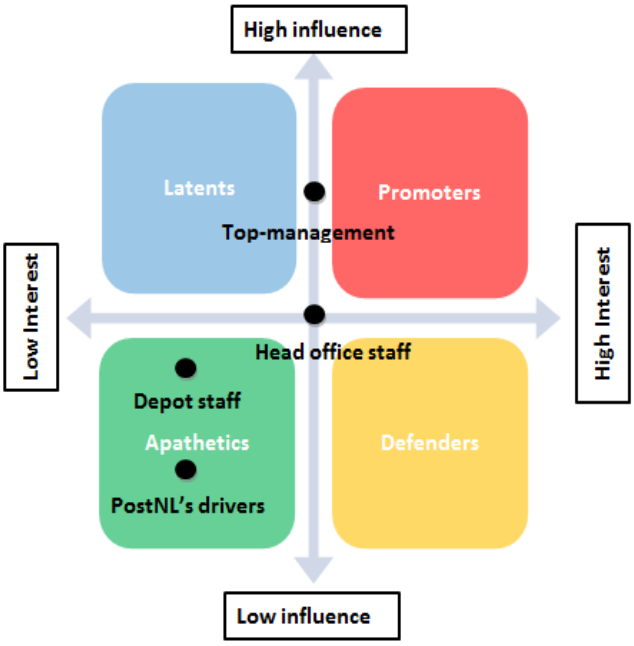

Figure 5 Internal stakeholder analysis

5.1.1.1. Top-management

Top-management has high influence on the project, since they have to agree whether they want to implement the project and whether they would like to invest in the project. The interest depends on the position of the person in top-management as well as the importance of the project for the corporate strategy. For example, some directors are more interested in the project especially when it falls under their direct supervision. Therefore, interest is categorized between high and low.

5.1.1.2. Head office staff

The head office staff must understand the importance of any changes and possibly execute them when applicable within their job. The interest differs among the staff for different projects. In the case of the reverse logistics of webshops, account managers of webshops are interested, since this adds an extra service for the webshops. Also, product management who designs different services is interested, since this adds an extra service to their portfolio. Other staffs are not that interested. Therefore, interest is again between high and low, and the influence of the staff is also between high and low.

5.1.1.3. Depot staff

The depot staffs are the employees handling the returns physically or are the ones that coordinate the returns at the depots. They do have some influence on the design of the practical implication, since they can give advice about the possibilities at depots. However, the end-decision will not be

made by them, therefore their influence is rather low. Their interest is also relatively low, since it only forces them to execute extra activities.

5.1.1.4. PostNL drivers

PostNL drivers have a fixed contract, so they have limited influence on whether they want to execute the extra services. Sub-contractor drivers do not have a fixed contract, so their influence is less limited. PostNL's drivers also have a low interest, since adding work or changing the way they do their current job is not something they favour.

5.1.2. External stakeholder analysis

The stakeholders in the external stakeholder analysis are derived from several articles mentioned before in the literature review (Koster et al., 2005; Janse et al., 2010; Lau & Wang, 2009; Pohlen & Farris, 1992). Figure 6 gives an overview of the external stakeholders and their positions with regards to their influence and their interest.

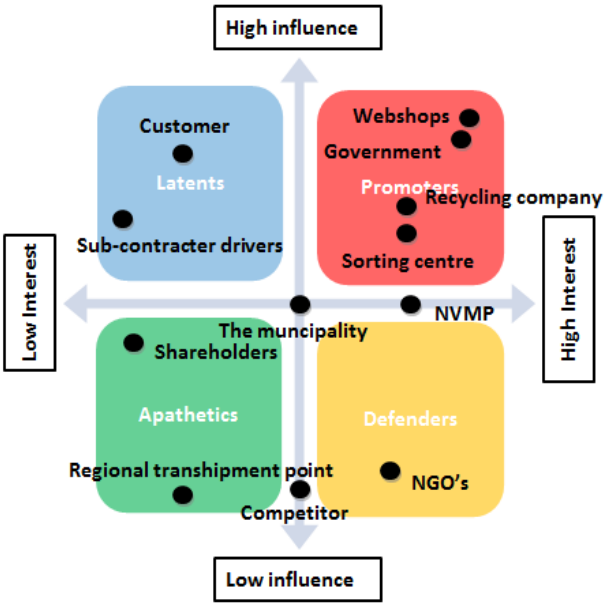

Figure 6 External stakeholder analysis

5.1.2.1. Customer

The customer has a major influence, since they are the actors that need to return their e-waste. If they do not send their e-waste back, there will not be any reverse flow. However, their interest is still rather low, since a lot of e-waste still ends up in the trash.

5.1.2.2. Sub-contractor drivers

The sub-contractor drivers are not interested in offering extra services, since this only gives them more work. However, their interest increases if they are financially compensated sufficiently. If they refuse to work, PostNL cannot offer new services, which gives the sub-contractor drivers a certain level of power. The influence of the sub-contractor drivers compared to the PostNL drivers is much higher, because if there are big changes in the services provided by the sub-contractors, the changes need to be implemented in new contracts. Since most of the drivers delivering parcels for PostNL are sub-contractor drivers, this is the type of drivers taken into account in the different networks.

5.1.2.3. Webshops

In order to comply with legislation, PostNL is designing the reverse logistics network of e-waste for webshops. Therefore, their interest is high. Their influence is also high, as they are the actors that mostly have to pay for the solution.

5.1.2.4. Government

The government has a high interest, since there is the need to increase the amount of e-waste collected from households due to EU legislations. PostNL is not the direct party that has to comply with the WEEE legislation, therefore the government does not have a direct impact on PostNL. However, when executing transportation and collection activities of waste, complying with legislations is a must. Moreover, the legislations are still evolving and being modified and the government is the stakeholder making these changes. Therefore, the government has not only a high interest, but also a high influence.

5.1.2.5. Recycling company

Recycling companies have a high interest, since the collection of e-waste via PostNL could provide them with a potential flow of materials. They also have influence on the whole reverse logistics chain, because a significant part of the economic viability depends on the amount that recycling companies are willing to pay for the e-waste. Their influence is lower than other actors such as webshops for the reverse logistics chain, as PostNL could decide to use another recycling company instead.

5.1.2.6. Sorting centre

Sorting centres might be one of the actors in the reverse logistics chain, if they are not part of other facilities such as a recycler. When being a separate entity, their interest in the project is major, since there is an opportunity for them to earn money. Moreover, they also have an influence on practical implications of the reverse logistics network and the cost of the different processes in the network. However, their influence is not as significant, since their services can be also executed by other parties as is the case for recycling companies.

5.1.2.7. The municipality

According to the RBEEA, the municipality, as a stakeholder, is the one responsible for offering sufficient options for a holder and distributor of e-waste to hand in their old electronics (VROM, 2004). Some sustainable minded municipalities such as Leeuwarden cooperate with external parties to collect more e-waste. Therefore, the municipality could be an important partner in the future, as they have a responsibility to offer collection points and some are open for new innovative ideas. At this point, they do not have a major influence or a significant interest, but they could have both in the future in terms of funding. Therefore, this stakeholder is ranked in between high and low for both the stakeholder interest and influence.

5.1.2.8. NVMP

"The NVMP Association works on behalf of manufacturers and importers to organize the collection and recycling of waste electrical and electronic equipment (WEEE) and low-energy light bulbs (collectively referred to as 'e-waste')" (Vereniging NVMP, 2012). The NVMP has a high interest in disposing e-waste in a proper manner and that is why they and their executing and managing party Wecycle could have a high interest in the reverse logistics activities PostNL is offering. They also have an influence, since they have a fund of money paid by producers to dispose of e-waste. When reverse logistics of PostNL are partly financed by this fund, their influence would become

significant. However, when the reverse logistics network exits without their funding, the influence is way lower. Therefore, their influence is ranked between high and low.

5.1.2.9. Shareholders

The shareholders have a minor influence on the implementation of new projects. It is the top-management that decides whether the reverse logistics of e-waste is implemented. Moreover, they have low interest in the different projects being implemented, since they mainly want to see financial returns.

5.1.2.10. Regional transhipment point

The regional transhipment point is probably assigned by one of the actors or fall under the supervision of one of the other actors such as webshops, recycling facility or PostNL. It could also be that a regional transhipment point is not included in the network. Therefore, its influence and interest are quite low. Some influence they could have is whether the activities are executable or not.

5.1.2.11. Competitors

Competitors are not a direct stakeholder of PostNL and therefore do not have a major influence on implementing reverse logistics of e-waste for webshops. Moreover, for the logistics companies, the main reason to do this is to keep their own customer base satisfied. It might be the case that the solution of competitors influences the solution of PostNL indirectly. Further, competitors might be interested in the solution that PostNL is offering, but it is not of PostNL's interest to keep them informed about their developments. In general, competitors are not the stakeholders accounted for when designing a new service, but it is a stakeholder to be aware of. Later in the paper, a short competitor analysis is given to get an overview of the solutions the competitors are implementing.

5.1.2.12. NGO's

NGO's have a high interest as could be seen from the attention Greenpeace devoted to the dumping of e-waste in developing countries (Greenpeace international, 2009). They currently do not have a direct influence on the reverse logistics activities of PostNL. However, NGO's might influence the government and their legislation policy indirectly.

5.2. Basic understanding of the legislation

In this section the legislations relevant for offering a service to webshops to return the e-waste from their customers is discussed, in order to get a basic understanding of the legislation. First of all, the WEEE directive is discussed, since this is the reason why the extra service is needed in the first place. The ROHS directive is not assessed more thoroughly than is done in the literature review, since the restriction of using certain material in your production process does not restrict the service offered nor does it restrict the network that is designed in this research. Moreover, the Basel convention is not relevant for this network, since for the e-waste of the webshops' customers a processing facility within the Netherlands is used. Therefore, this network does not involve cross border waste transportation. The buyers of the recycled material could be in for example Asia but this material is not considered as waste anymore.

5.2.1. Description of WEEE directive

The market expansion and shorter innovation cycles result in EEE being a major growing source of waste. The content of hazardous components in EEE is a major concern during waste management, and recycling of WEEE is not done sufficiently. A lack of recycling results in the loss of valuable resources. Therefore, the WEEE directive 2002/96 came into force in 2002. The goal of this directive is to contribute to sustainable production and consumption of EEE. This should first tried to be done by the prevention of WEEE and otherwise by the re-using, recycling or another form of recovery of WEEE. This will contribute to a reduction in the disposal of waste and to the efficient use of resources and the retrieval of valuable secondary raw materials. One of the measures to achieve this is by setting collection rates for all the member states.

The latest revision of the directive in 2012 included new collection rates. From 2016, the minimum collection rate will be 45 % of the average weight of EEE placed on the market in the three preceding years in that Member State. From 2019, the minimum collection rate to be achieved annually will be 65 % of the average weight of EEE placed on the market in the three preceding years in the Member State concerned, or alternatively 85 % of WEEE generated on the territory of that Member State (European Union, 2012). Every member state transposes the WEEE to their national law in their own way and should set their own measurements to achieve the collection rates. In the Netherlands the WEEE is transposed to the Dutch Directive called "Besluit en de Regeling beheer elektrische en elektronische apparatuur", also sometimes referred to as Reea and Beea. The latest version of the WEEE still needs to be incorporated in the last version of the RBEEA.

5.2.2. Relevance of the WEEE legislation on the project

Since the WEEE legislation is quite extensive, only the main articles of the WEEE directive relevant to the webshops or to other players in the network are discussed.

Under the WEEE legislation, all webshops can be classified as distributors and some are also classified as producers. A distributor according to the definition of the directive 2012/19/EU is: "Any natural or legal person in the supply chain, who makes an EEE available on the market. This definition does not prevent a distributor from being, at the same time, a producer (European Union, 2012). Being at least a distributor of EEE goes hand in hand with some responsibilities.

First of all, the Directive states that the obligation of producers and distributors using distance and electronic selling channels should take the same form and be enforced in the same way as other distribution channels for as far as it is practicable. In this way, other distribution channels do not bear the cost of the webshops. Article 4 of the Reea states that when the distributor makes a new product available, they should offer to take back an obsolete comparable EEE that has come available after use. This article is referred to as the "nieuw voor soortgelijk oud regeling", translated to "the new for comparable old collection obligation". The WEEE is comparable when the EEE executes the same functions as the old one, irrespective of brand and size (VROM, 2004).

The users of EEE from private households returning their obsolete EEE under this collection obligation should have the possibility to return WEEE at least free of charge. This group should therefore not be charged for the disposal of WEEE. Producers, on the other hand, should at least finance the collection from collection facilities and the treatment, recovery and disposal of e-waste (European Union, 2012). For webshops, this means that they have to offer a take-back possibility for the WEEE at the moment of transferring the new EEE to the consumer, free of charge. The transferring of the EEE is done by a parcel delivery company or at a post office.

Another obligation under the Beea is the "mededelings verplichting", translated to the "announcement obligation". The announcement obligation is mandatory for every producer for who the Reea has become applicable. This group should fill in a form for the Minister stating how they will comply with the applicable articles of the directive within 13 week after they have started to conduct business that falls under the Reea (van Geel, 2004).

The WEEE also states that member states should provide for proportionate and effective penalties when the legal or natural responsible person in charge of the waste management infringes the obligations of the directive (European Union, 2012). In order to be able to ascertain such an infringement, inspections need to be executed. In 2012, inspections were performed by the Inspection living environment and Transportation (ILT), part of the Dutch Ministry of Infrastructure and Environment. These inspections were conducted after a warning letter was sent with regards to the Reea and Beea by the Ministry of Infrastructure and Environment. Specific attention was given to the new-for-old collection obligation (article 4 Reea) and the announcement obligation (article 4 Beea). Around 30 companies, being responsible for 100 webshops together (Thuiswinkel, 2013) were inspected. It appeared that many companies did not comply with the new-for-old collection obligation and some also did not comply with the announcement obligation. A second warning letter was sent, announcing a second inspection starting from September 2012. When webshops do not comply with the legislation, a fine could be given over the amount of e-waste a webshop is responsible for, going back to the year 2005 (Van der Velden, 2013).

As stated before, there are many more articles that should be checked when being a distributor or producer of e-waste. However, the articles mentioned above are the most relevant articles and also the ones currently being inspected by the ILT.

5.2.3. Waste transportation and collection compliance

Besides the WEEE directive, there are also legislations to comply with when transporting, collecting or handling the e-waste. First of all, as a transporter or collector of waste, you need to be registered on a list such as the VIHB-list, as stated in the Wet Milieubeheer (Stichting vervoeradres, 2012). Moreover, when transporting, you need to have a "guidance form", which is a guidance letter that involves the necessary information flows between the receiver and disposer of e-waste at every part of the chain. As a collector of e-waste, you also have to comply with the Besluit Inzamelen Afvalstoffen, which is part of Environmental management law and regards the decision of waste collection. In order to be allowed to collect waste, the collection facility sometimes needs to also have a permit. Moreover, most of the time, the party collecting the waste has an obligation to

report the amount of collected e-waste to the Landelijke Meldpunt Afval (LMA) (Stichting vervoeradres, 2012). An extensive overview of the legislations and their effect on the operation within the reverse logistics network is discussed in chapter 7.

6. Supply chain configuration and management

6.1. The possible network structures

In order to be able to design a suitable reverse logistics network for PostNL for the e-waste of the customers of webshops it is necessary to first understand PostNL's forward parcel distribution network.

6.1.1. PostNL's forward parcel network

For the explanation of the forward network the example of a customer sending a parcel via a post office in Bussum towards an address in Goes is used. Figure 7, together with table 2, explains the forward parcel distribution.

Figure 7 Flows in the forward parcel distribution

	Explanation of the flows in the forward
1	Consumer hands in parcel at post office
2	Transportation of mail and parcels from post office to BuBa
3	At BuBa the parcels are split from the mail
4	The parcels are transported to depot Utrecht (1/18 depots of PostNL)
5	The parcels are sorted at the depot per: delivery address, route, shift and the closest depot to the end destination
6	The parcels are transported in a truck in roll containers from depot Utrecht to X-dock depot (1/3 PostNL x-dock depots) for the southern part of the Netherlands
7	Parcels are cross-docked at depot Den Bosch to go to depot Goes
8	The parcel is transported from depot Den Bosch to depot Goes
9	The parcels are sorted at the depot Goes per shift and route
10	PostNL driver transports the parcel from depot to the delivery
11	Parcel reaches final destination

Table 2 Explanation of the flows in the forward parcel distribution

6.1.2. Network in response to environmental take-back legislation

The reverse logistics network for the e-waste from the webshops' customers is driven by the WEEE legislation. Due to this take-back legislation, webshops have to find a solution to take back the e-waste from the consumer as is explained in chapter 5. PostNL's motivation to offer this take-back service is economical; to earn extra money and/or to offer an extra service to keep their existing client base satisfied. However, since the total network is legislation driven, this is the basis for the design of the network.

Fleischmann (2001) identifies five types of reverse logistics networks; one of them is set up in response to environmental product take-back legislation. This type of network is a good basis for the network for the e-waste from the customers of webshops. A graphical display of such a model can be found in **Appendix B.**

The model assumes that the first mile in the reverse logistics network is taken care of by the consumer, who brings their old products to a retailer, drop-location or to a municipal waste collection scheme. The collection and the reprocessing activities in the network are generally outsourced to logistics service providers and specialized recycling companies. The typical form of reprocessing is material recycling. The focus is mostly not on recapturing value but on cost minimization, therefore it can also be stated that testing and grading is not so important. The costs are charged to the consumer either directly or via the price of new products. This model is based on an industry-wide co-operation in the collection and reprocessing of e-waste rather than an individual system (Fleischmann, 2001).

6.1.3. Network in response to take-back legislation adapted to PostNL´s service

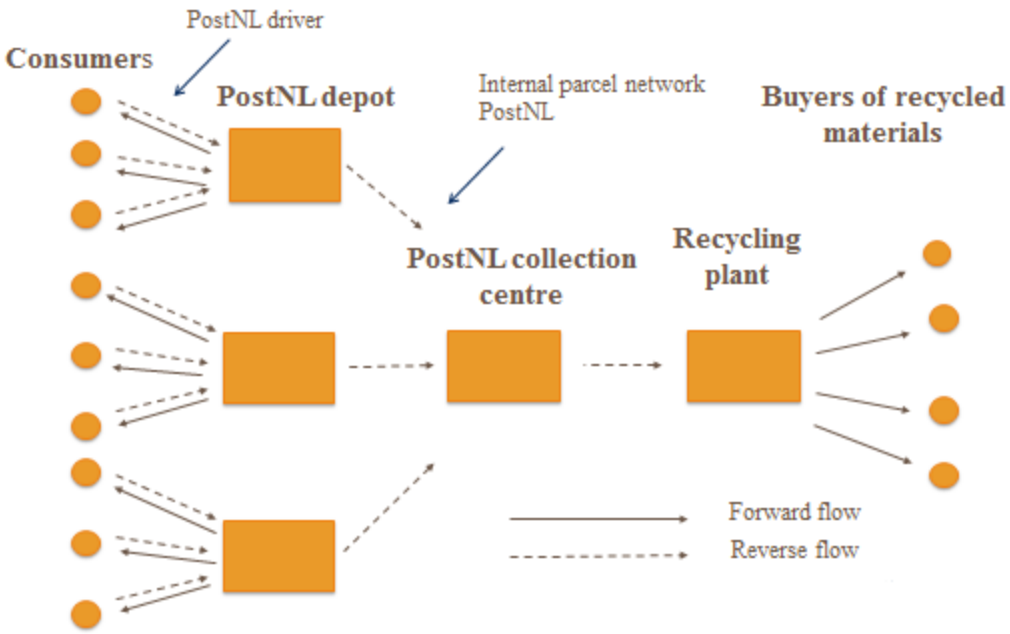

Figure 8 Network in response to take-back legislation adapted to PostNL's service

Figure 8 displays the take-back model adapted to PostNL´s reverse logistics network for the e-waste of webshops and is considered as PostNL's base model. Since the webshops have to offer a possibility to take back the e-waste at the moment of transferring the new product, PostNL assumes control in this model after the first mile and brings the e-waste to one of their depots instead of bringing it to a retailer. This could be done in terms of a spontaneous return as is currently the case at PostNL. A spontaneous return means that a customer can give back their e-waste to a driver when new equipment is being delivered, without announcing this beforehand. After that, the old product is transported to a collection centre. In the case of PostNL the transportation from the depot to a collection centre is done by using the internal parcel network of PostNL as explained in the forward logistics network. It is possible to use the internal parcel network, since the e-waste needs to be

properly packed and consist of a reply mail address when being sent. From the collection centre the e-waste is brought to the recycling plant. The transportation from the collection centre to the recycling plant is organized by the recycling plant, which either executes the transportation themselves or arranges the transportation via a third party such as Wecycle. Last, the recycled materials are sold to buyers of recycled material. In the base model, PostNL is the collector of the e-waste and this system is a collective system for all the webshops that use PostNL services. Moreover, the collection centre is solely used to collect the e-waste in order to ship it to one recycling plant. The depots are not used as collection centres, but solely as transhipment points. The variations of the base model are discussed below.

6.1.4. Variations of the base model

The variations of the base model are based on ideas gathered from several internal meetings with employees of PostNL and ideas gathered from the literature. The variations of the model are discussed in a systemized way starting with the different collection possibilities and finishing with the variations at the processing facility's side. The different tables per section give an overview of the possible variations and in which network options these variations are visible, followed by a more detailed description of the different possible network options. The variation might be present in multiple options, since sometimes multiple variations are combined in one option in order to keep the explanations more concise. After that, the first evaluation and elimination of the options follows. The first elimination and evaluation of the possible network options is based on literature and PostNL's point of view. Further, elimination is done in the later sections as explained in the methodology. Since PostNL is a collector of e-waste in the base model, the different options of PostNL as a collector are described first, followed by PostNL in the role as a transporter.

6.1.4.1. Variation in the means of collection

Corresponding option numbers	Explanation of the variation
Option 1	Using a dedicated collection route instead of an integrated?
Option 2	Using post offices as collection points instead of drivers picking up the e-waste?

Table 3 Variation in the means of collection

1. A dedicated collection route could be a solution. In the base model the collection of the e-waste is integrated in the forward logistics supply chain. Deciding on whether you should have an integrated or dedicated reverse logistics supply chain is one of the main decisions mentioned in Fleischmann (2001) in regards to designing a reverse logistics supply chain.
2. The collection of the e-waste can also be done at a post office, which is then used as a collection point. This option needs to co-exist next to options of the sub-contractor picking up the e-waste from a customer, since also at a post office EEE is transferred to a customer. In the base model the consumer also brings its waste to a collection point. In that network the returned products are transported directly from a collection point to a collection centre. In this network the e-waste brought to the post office follows the same distributions as the parcel in the example of the forward

network being brought to a post office for a certain destination. Thus, it is first brought to a depot and from there it is sorted and sent to the collection centre.

6.1.4.2. Evaluation and elimination of collection side variations

Option 1 can be eliminated. Generally integration is preferred over dedication. Fleischmann, Beullen, Bloemhof-Ruwaard, & Van Wassenhoven (2001) concluded that mostly the fixed forward network structure does not impose sufficient boundaries on the design of an efficient reverse logistics network structure. When the end destination of the reverse goods is different from the forward location the goods depart from, dedication could be preferred over integration (Fleischman et al., 2001). In this network that is not the case, so it is better to integrate. Moreover, in terms of having high truck utilization, integration is preferred over dedication. This is also applicable to PostNL's network.

In literature **option 2** is preferred over the base model, since the transportation cost of first mile transportation is considered as a significant burden. Also transporting the first mile is considered as transporting in an unsustainable way (Fleischmann, 2001). However, in the case of PostNL there are already trucks driving on the route of the first mile, so no extra kilometres are driven to collect the e-waste from the customer. Moreover, picking up the e-waste from the consumer can be seen as an advantage for the consumer. This makes the collection very convenient since they do not have to leave their house to dispose of their e-waste. Moreover, the e-waste is brought to a depot but first passes a post office instead of being transported directly to the depot by a driver. This option could therefore be even more costly. As stated before, in order to comply fully with legislation both options need to co-exist. However, a preferred option could be picked based on an evaluation of the different collection options in later chapters.

6.1.4.3. Variation regarding depots

Corresponding option numbers	Explanation of the variations
Option 3-8	Using all or only several depots?
Option 3, 4, 5 and 7	Depot also a collection centre?
Option 6 and 8	Depot also a sorting centre?
Option 5 and 7	Consolidation point needed or directly transported to reprocessing facility?
Option 5 and 7	Using PostNL's cross dock to consolidate or using a dedicated consolidation point?

Table 4 Variation regarding depots

3. The 18 PostNL depots also function as a collection centre of e-waste instead of solely as a transhipment point, from which the e-waste is shipped directly to one recycler or regional recycler. In this case PostNL collects the parcels per district early in the network and without further consolidation it would be shipped to the recycling facility.

4. Only a few PostNL depots function as a collection centre. The transportation to these specific depots is done through the parcel network. From these depots it is transported directly to one recycler or a specific recycler per selected depot.
5. The 18 PostNL depots function as a collection centre from which e-waste is shipped via a consolidation point to one recycler or multiple recyclers. This consolidation point could be one of PostNL's cross dock depots. Another option is to use a dedicated consolidation point. For this option, the parcels will first be shipped to a PostNL depot that functions as a collection centre. From there it is transported via a dedicated truck to a dedicated consolidation point. From the consolidation point it will go to one or multiple recyclers. The latter one is inspired by the reverse logistics network in Denmark, **see appendix B** (Grunow & Gobbi, 2009).
6. This option is the same as option 3 only the depots also function as a sorting centre. From there e-waste will be transported to one or multiple recyclers, either directly or with the use of consolidation points.
7. This option is the same as option 5 but now only a few depots function as a collection centre from which it is shipped via a consolidation point being a PostNL cross dock location or a dedicated consolidation point to one or multiple recyclers.
8. This is the same as option 4 only for this option some depots also function as a sorting centre. From there it will be transported to one or multiple recyclers, either directly or with the use of consolidation points.

6.1.4.4. Evaluation and elimination of depot variations

Based on practical implications all the options regarding using the depots as a collection centre and/or sorting are eliminated (**3, 4, 5, 6, 7 and 8**). At most depots there is no space or only very limited space to collect the e-waste instead of transhipping the e-waste right away (Project manager e-waste, internal communication, August 27, 2013).
Moreover, most options deviate a lot from PostNL's normal structure, while the strength of PostNL is doing a lot of the same transportation without having too many exceptions. The chance of more errors when dealing with the exceptions and the fact that there is insufficient space at the depots are grounds to eliminate options concerning using the depots as collection centres and/or sorting centres (Department processes design PostNL, personal communication, August 9, 2013). Furthermore, the costs of using depots as a collection centre and/or sorting centre are most likely higher than other options. Using the depots as a collection centre and/or sorting centre, means the collection and or sorting centres are decentralised, resulting in a higher facility costs. Also, for the option when the e-waste is transported to a reprocessing facility from multiple depots without being consolidated first, the transportation cost will likely also be higher.

6.1.4.5. Variation regarding collection centre

Corresponding option numbers	Options
Option 9, 11	Only collecting or also other activities such as: unpacking, sorting, testing and repairing or only some of these activities?
Option 10, 11	Centralized or decentralized?

Table 5 Variation regarding collection centre

Some of the following variations are based on the decision whether testing and grading facilities should be centralized or decentralized. The trade-off in terms of cost is between transportation cost and facility investment cost. Testing and grading are important activities to determine the recovery activities of the waste equipment. Testing collected equipment in an early phase could minimize total transportation cost, since the products can directly be sent to the corresponding recovery operation. However, it increases the amount of testing facilities needed (Fleischmann, 2001). Moreover, whether the other activities should be conducted also depends on the additional cost it imposes and the possible extra gains it results in. Another option is to add repair activities after the testing of the goods.

9. The collection centre is not only used for the collection of the e-waste but also for unpacking and/or sorting and/or testing and possibly repairing. In this way PostNL might get a higher price for the sorted material from one reprocessing facility or from different reprocessing facilities.

10. Instead of using one central collection centre, a decentralized collection centre without extra activities per region could be used. The e-waste could be transported all to the same recycler or to different recyclers (different per region or waste stream).

11. The same as option number 10 only including the extra activities enabling to send it also to different reprocessing facilities in regards to who wants to have the different equipment and materials.

6.1.4.6. Evaluation and elimination of collection centre variations

For these options there is not yet an elimination based on PostNL point of view or the literature. These options depend on whether a higher price is given for the e-waste when sorted, tested and repaired. Moreover, whether decentralization is possible depends mostly on whether it is feasible to use multiple sorting centres and whether the reduction in transportation costs offsets the increase in facility cost.

6.1.4.7. Variation regarding reprocessing facilities

Corresponding option numbers	Options
Option 12	One or multiple: Regional or central? One for all material or a separate one per waste stream?
Option 13	Only recycling or also reuse?

Table 6 Variation regarding reprocessing facilities

12. The e-waste will be sent to different reprocessing facilities either since the reprocessing is organized regionally or since it is organized per different waste stream. Organizing the reprocessing facilities regionally could be beneficial, since it decreases the transportation cost. However, it increases the facility cost. A separate reprocessing facility per waste stream could increase the gains received for the materials.

13. In the base model the collected e-waste will be recycled. However when the e-waste is sorted, it could also be tested on whether it still functions. The defective equipment could also be

repaired. Based on this, some equipment such as desktops could be reused instead of being recycled (Ravi, Shankar, & Tiwari, 2005).

6.1.4.8. Evaluation and elimination of reprocessing facility variations

In order to decide whether the e-waste should be recycled and/or reused mostly depends on the economic incentives of these activities. Whether multiple processing facilities are used depends on factors such as the volume in the network and the facility and transportation cost. Therefore, in this stage no preference can already be given to an option and therefore further elimination is done in the later stages of this research.

6.1.4.9. The network options left for PostNL as a collector

At this point of the research the options at the collection side left are: the sub-contractor driver picking up the e-waste from the customer at the point of delivery and the customer bringing the e-waste to the post office. All the options of using a depot as a collection centre or sorting facility are eliminated. All the different options in regards to the collection centre and recycling facility have not been eliminated and are further evaluated in later stages of the research.

6.1.5. Solutions when being only the transporter of e-waste

In the base model PostNL's role is being a collector and therefore they provide the webshops with a collective solution. Another possible role identified in chapter 4 was solely being a transporter. Below two options explaining which part of the transportation of the reverse logistics network PostNL could execute are identified. These options are based on some existing networks discussed in literature with regards to the reverse logistics of e-waste.

Corresponding option numbers	Options
Option 1	Parcel is sent to the reply number of a webshops, corresponding with their own DC or a regional transhipment point
Option 2	E-waste directly transported to reprocessing facility

Table 7 Network options roles as a transporter

1. PostNL is only a transporter of e-waste and picks up the e-waste from the consumer and sends it with their parcel network to the reply mail number of the webshops. The reply number could correspond to the DC of the webshop or a regional transhipment point. These two collection points would be the same as the ones being used in the collective system designed by the NVMP for end-of-life white goods (de Koster et al, 2005). **See appendix B** for the structure of the network. The transportation that PostNL executes is the transportation that is not being paid for by the NVMP as is the case for the end-of-life white goods. Therefore, the retailers and in this case the webshops have to find their own solution for this kind of transportation. In this case the webshop has an individual collection system and solely uses PostNL to transport the e-waste in order to collect it themselves. There are already some webshops in the market who use this system. An advantage of individual collection system for the webshop is that it gives webshops greater control over the end-of-life product management. For webshops selling products containing precious

metals, such as cell phones and computers, recovering these discarded products by themselves could become a profitable business (Esenduran, 2012). PostNL would get paid for their transportation service.

2. PostNL is only a transporter of e-waste and uses its network to send the e-waste in parcels directly to one recycler or multiple recyclers. The advantage of this is that the e-waste does not have to pass any other facilities, limiting the facility costs.

6.1.5.1. Evaluation and elimination role as a transporter

At this stage none of the network options for PostNL as a transporter are eliminated, since this mostly depends on the preferences of the webshops. A transporter does not decide the destination of the e-waste. Whether the e-waste can be directly transported to the processing facility also depends on the capabilities of those facilities. These network options together with the network options left for PostNL as a collector are further analysed.

In order for the network options to work optimal a financial structure and information flows are required. These are explained in the sections below.

6.2. Financial structure

This network is legislation driven rather than economic, which mostly complicates the factor of which actor finances the different parts of the network. In order to have an optimal network a financial structure should be in place. The e-value stream pays for its own network, since money can be earned with this stream. E-waste is different, since some equipment is worth some money but not sufficient to pay for the whole network. How much the different networks cost and benefit is addressed in the performance chapter, this section focusses solely on the financial structure.

6.2.1. Financial structures in general

In the literature several financial structures have been discussed in regards to the collection of e-waste. Almost all options involve the consumer indirectly or directly paying for the recovery and transportation of e-waste (Kahhat, et al., 2008). However, for most structures the producer is responsible for collecting this fee from the consumer (Magalini & Huisman, 2007). With this fee the producer either finances his own recycling system or gives this fee from the customer to a fund of a collective system, managing the recycling of materials for several producers. In Japan the recycling fee and additional fee for the e-waste has to be paid by the consumers. In this system it is the responsibility of the retailer to collect and release obsolete products from consumers (Kahhat, et al., 2008). In South Korea they also have a system in which a producer pays money to a recycling fund. In this program the producer receives its money back, based on the amount they recycled either by executing these activities themselves or by outsourcing it (Yoon & Jang, 2006).

6.2.2. The Dutch system

In the Netherlands a visible disposal fee had been paid by the consumer on top of the prices of the products in order to pay for the proper disposal, recovery and the transportation of the e-waste. In the Netherlands the NVMP manages the collective system of the e-waste for 1600 producers and importers. The money from the disposal fee of these producers and importers was transferred to the

fund of the NVMP. The NVMP assigned the party Wecycle to execute the collection, recycling and transportation of e-waste for them (Producenten verantwoordelijkheid Nederland, 2013).

However, since 2013 the visible disposal fee has been abolished for big white goods and for small e-waste it has already been abolished since 2011. This means that the disposal fee has now been incorporated in the price, with the purpose of the producers and importers to pay fully for the cost. Since 2013, the producers and importers that are part of the collective system get an invoice related to the amount of equipment put on the market by them. The money that is currently in the NVMP fund is used for the e-waste of products put on the market before 2005 (Producenten verantwoordelijkheid Nederland, 2013). Producers and importers that take part in the collective collection system of Wecycle receive a compensation for the costs they face due to the collection and release of e-waste. The compensation is based on the amount of e-waste released to Wecycle (Wecycle, 2013). An interesting note about this compensation is that recyclers who are not part of the collective collection system of Wecycle are willing to give producers a higher compensation for the e-waste than Wecycle.

According to legislation, the producers should carry the financial responsibility of e-waste. Moreover, the consumer should not be charged a visible disposal fee anymore when buying a new product and should also be able to take part in any take-back system free of charge. On this will be further elaborated in chapter 7.

6.2.3. The end-of-life white goods network

In literature the financial structure for the network for the end-of-life large white goods in the Netherlands has been described in detail. The buyer of a new product pays a fee which goes to the NVMP. The cost for the collection of white goods from the customer at the retailer is paid by the retailer. The retailer either brings it to their own DC in case they have one or to a regional transhipment point, still bearing the cost themselves. From the DC, transhipment point and sometimes directly from the retailer without DC, a selected carrier is paid by the NVMP to transport the white goods to a selected processor. The selected processor and the regional transhipment point receive a fee from the NVMP. The regional transhipment point also gathers the waste from the municipalities. Currently, the financial flow towards the NVMP fund is not the fee from the consumer but the fee from the producers, as described before (de Koster, Flapper, Krikke, & Vermeulen, 2005).

The current financial structure of PostNL's network is similar to the end-of-life white goods network. The similarity is obvious, since now the webshops are the retailers in the network. This means that the processor and the transportation to the processor need to be funded by the NVMP. The sorting facility is a player not recognized in the white good network. In the white good network there are only storing places recognized. Therefore, the sorting facility falls under the financial responsibility of the webshop.

Hence, the financial structure is as follows: all the activities including the activities at the sorting facility need to be paid by the webshops. The transportation to the recycler and the activities of the recycler are funded by the NVMP when releasing the collected e-waste to Wecycle. The webshops

gain compensation from Wecycle or another recycler for the amount of e-waste they have collected and released to one of these parties. The compensation for the e-waste is based on the market prices of the material and is therefore volatile. Therefore, the total cost of the whole network can differ, due to the changes in the fee paid for the e-waste (Recycler1, personal communication, August 6, 2013).

In the situation described above, the webshop has to bear most of the cost of the network, which is not preferred by the webshops since they want to pay the least possible for the extra service. Since the other stakeholders are executing the activities in the take-back network for the webshops, it is not possible to let them pay for the network. However, not letting the webshop bear all the cost of the network is also in the other stakeholder's interest, since they would like to have a higher volume as is elaborated on in chapter 7. This financial structure is the same irrespective of the role of PostNL. In order to reduce the amount that needs to be paid by the webshops, other financial structures need to be considered.

6.2.4. Other financial structures

Other options could be to cooperate with the municipality, since they also have a collection responsibility like the webshops as explained in chapter 5. The municipality also receives some funding from Wecycle for their collection systems. Moreover, the transhipment points where the equipment from the municipality is transported to are also funded by the NVMP (de Koster, Flapper, Krikke, & Vermeulen, 2005). Another reason to cooperate with municipalities is that some municipalities such as Leeuwarden would like to have a sustainable image. Therefore, they are willing to invest in some other collection systems.

An ideal financial structure would be when the producers are financially compensated for the amount of e-waste they collect, directly from the NVMP fund irrespective of what system they used to collect the e-waste. This is the case in the South Korean system. When the products of a producer are collected by another system than executed by Wecycle, it would be fairer if they receive more compensation than only getting a small compensation for the collected e-waste from Wecycle. This is fairer because Wecycle does not incur the usual cost of collection and transportation. Moreover, due to the prices the recyclers are willing to give for the e-waste, it would be better to release the e-waste to one of the recyclers instead of giving it to Wecycle. However, this means that no money from the NVMP fund is spent on collecting this stream of e-waste, while money to properly dispose of this equipment is paid by the producers of the equipment to the fund. It would be reasonable if the other take-back systems not managed by Wecycle, also receive compensation for their activities and not just for the amount of e-waste. This involves changing the system. Currently, some parties are trying to change this and to create competition in the market. However, changing the structure is quite complex and is not expected to happen in the near future.

6.2.5. Conclusion

In conclusion, in the current system the webshop needs to pay for most of the activities in the network. Since this limits the volumes going through this system, other options should be explored. There are some alternatives but this means collaboration needs to be sought or a whole system needs to be changed, which both will not happen in the near future. Therefore, for now the

webshops need to pay for the activities in the network and they could gain some money from the fee paid for the amount of e-waste by Wecycle or a recycler.

6.3. Information flow

In order to design an optimal network, exchanging information between the different players within a supply chain and outside the physical supply chain is necessary. Some of these important information flows mentioned in the literature are briefly addressed. After that figure 10 and table 8 explain all the different information flows needed in this specific take-back network.

6.3.1. General explanation of the information flows

It is important to gain information about the product after the point of sale, since this makes it easier to decide on the destiny of a product at the end-of-life (Janse, Schuur, & de Brito, 2010). Another beneficial information flow is attaining the information of the amount of obsolete WEEE per country. Different models per country are used in order to estimate the amount of WEEE. In the Netherlands the consumption and use method is used to estimate the potential amount of WEEE. This method takes the average amount of electrical and electronic equipment of a typical household as the basis for their estimation of WEEE. (Widmer, Oswald-Krapf, Sinha-Khetriwal, Schnellmannc, & Boni, 2005).

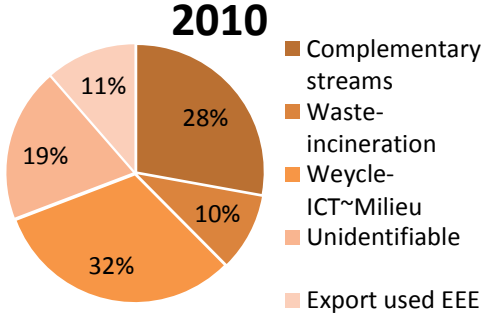

Figure 9 Dutch WEEE Flows

In the Netherlands Wecycle, has set up a registration system in order to get better insights in the amount of e-waste being processed. In the report "The Dutch WEEE Flows", it was stated that 26.5 kg of EEE per inhabitant was put on the market in 2010, based on a methodology that uses production, import and export data for EEE from Statistics Netherlands. In total in the same year there was 23.7 kg of e-waste per inhabitant. Figure 9 gives an overview of the division in 2010 of WEEE (Huisman, van der Maesen, Eijsbouts, Baldé, & Wielenga, 2012) .

Another information flow mentioned in literature in regards to a take-back network is the importance of exchanging information in order to know from where to where the e-waste is being transported, by whom is it being transported and how much is being transported. Further, it highlights the importance of information flows needed to determine which party needs to pay or needs to be paid for the activities in the network (de Koster, Flapper, Krikke, & Vermeulen, 2005).

6.3.2. Explanation of the information flows

Figure 10 displays all the information flows between different actors within this specific take-back network. The numbers in Table 8 correspond with the numbers in the diagram, explaining which information is exchanged between the parties. A distinction is made between three groups: the facilitators, the physical parcel distribution and the controlling bodies. The facilitators receive and give information to the physical parcel distribution. The physical parcel distribution contains the information flows between all the actors that physically handle the parcels. Last, the controlling

bodies mostly receive information from the actors executing the physical handling of the parcel, which they have to monitor. Most of the information flows are based on legislation or on information from the stakeholders.

Figure 10 describes the network for PostNL in the role of a collector. It is assumed that the sub-contractor transport less than 500 kg of e-waste per vehicle. In case more than 500 kg of e-waste is transported in one vehicle, the guidance form between the different actors should be added to the diagram. This includes the disposer or collector giving the receiver information about the waste that is transported. The receiver has to provide the disposer or collector with a waste flow number referring to the waste, which has to be reported on the guidance form. Another assumption in the diagram is that the depots and the sorting facility do not have a reporting responsibility towards the LMA. When the depots and the sorting facility have a reporting responsibility, there is also an information flow from those facilities to the LMA. All the information flows related to legislation, are further explained in chapter 7.

Other factors not taken into account are: the government has to inform all the different actors about the importance of such a take-back network, NIWO needs to be informed about the registration on the VIHB-list by the sub-contractor driver and PostNL and all the parties active in this network have to keep an administration of the transported and handled e-waste. On all these factors a further explanation is provided in chapter 7, however in order to give a complete overview, they are mentioned in this section.

6.3.3. Information flows PostNL in the role of a transporter

The information flows would not change majorly when PostNL is solely a transporter. The main difference is that some information flows that in the current model are directed to PostNL go directly to the webshops, since webshops will have the more coordinating role in this network.

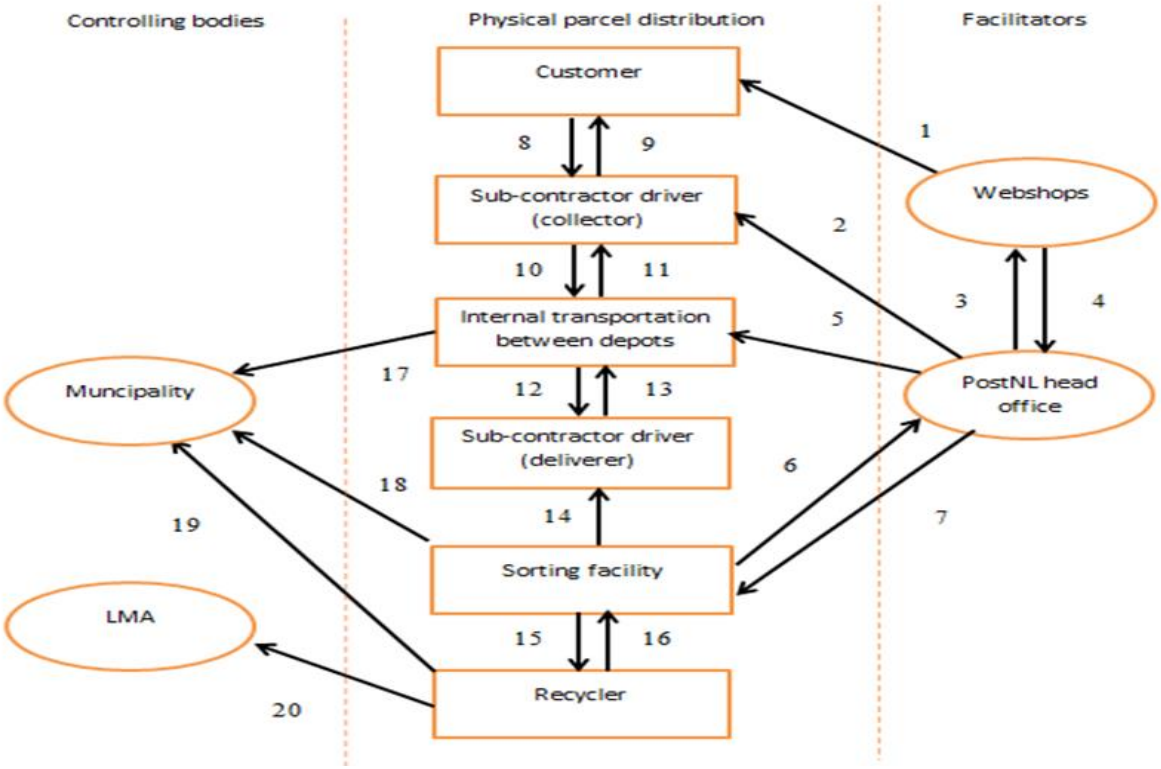

Figure 10 The information flows in the take-back network

	Information flow
	Facilitators
1	The webshop informs the customer about the possibility to give e-waste to the driver and about the requirements of the carton box of the e-waste.
2	PostNL head office informs the sub-contractor driver about the new service and the activities the service requires from the subcontractor driver.
3	PostNL head office informs the webshop about the take-back service they offer.
4	Webshop informs PostNL head office about which service they would like to have.
5	PostNL head office informs the staff (especially at depots) about the new return service.
6	Monthly invoice to PostNL for the different activities the sorting facility executed and the specification of the e-waste for the different webshops.
7	PostNL provides the sorting centre with a list containing the amount of webshops and the corresponding reply number, in order for the sorting facility to execute the reporting.
	Physical parcel distribution
8	The customer tells the driver they want to give back a parcel of e-waste and provides the parcel with the reply mail number
9	The sub-contractor driver checks whether the parcel fits the requirements and gives a receipt to the customer
10	The sub-contractor driver reports returned parcel at the information desk of the depot
11	Information desk adds the returned parcels to the payslip of the driver subcontractor
12	Depot provides the subcontractor with the information about the route and the parcels
13	Sub-contractor driver reports to the depot that a parcel has been delivered via the handheld device of the subcontractor driver.
14	The sorting facility confirms receiving the parcel from the subcontractor driver
15	The sorting facility contacts recycler when having a full container of e-waste
16	The recycler informs sorting facility about the amount and quality of the e-waste
	Controlling bodies
17	Report the activities of the facility under the activiteitenbesluit or for the omgevingsvergunning
18	Report the activities of the facility under the activiteitenbesluit or for the omgevingsvergunning
19	Report the activities of the facility under the activiteitenbesluit or for the omgevingsvergunning
20	Recycler has to reporting responsibility to report three things: receiving of the waste, monthly receiving of the waste and the releasing of the waste.

Table 8 The information flows in the take-back network

7. In-depth analysis legislation and stakeholders

7.1. Requirements legislation per role

In this section, the effects of the legislation on different possible roles of PostNL and the effects legislation has on the operations are discussed. This section starts with discussing the effects when PostNL is a transporter in the network and then when PostNL is a collector in the network. Some criteria of the legislations are the same for both roles. In order to determine which criteria of the legislations the actors and activities in the network have to comply with, it is important to identify whether the waste transported is hazardous or not. For this research, we consider this stream of e-waste not to be hazardous, since the e-waste packed in a box by the consumer is not allowed to contain any liquids or oils. Also, almost all equipment with batteries, which are considered hazardous, are part of the high value stream that is not part of this research. To make sure that the e-waste does not contain batteries, the customers should be informed about the fact that they should remove the batteries from the equipment.

7.1.1. Transporter

7.1.1.1. VIHB list

As described before, a transporter needs be registered on the VIHB list or needs a permit in order to be able to transport waste. PostNL is currently registered on this list and therefore complies. However, most of PostNL's drivers are sub-contractor drivers, so it is their own responsibility to get the permits accordingly. When the sub-contractor drivers already possess a NIWO Euro transportation license, the registration on the VIHB list only involves filling in a form and the application is free of charge. A NIWO Euro transportation license is an operator's license for transportation companies. For the operations, this means that all the drivers need to have a certified copy of the VIHB registration when transporting the e-waste (NIWO, 2012).

7.1.1.2. Guidance form (begeleidingsbrief)

In general, when transporting waste, a driver needs to have a correctly filled in guidance form (begeleidingsbrief) on him. A guidance form is a letter giving an overview of the needed information for transporting waste. The disposer of the waste has to fill in the guidance form and hands it over to the driver of the transporting company. The guidance form has a standard layout set in the "besluit melden en de regeling melden" (reporting's resolution and reporting's regulation) of waste. This resolution and regulation state how to report any activities related to waste. The guidance form consists of three layers. The first layer is mandatory for everyone, consisting of the different actors handling the waste and the collection and delivery address. The second layer needs to be filled in when the receiver has a reporting responsibility and the third layer is not mandatory. In **Appendix C,** an example of a guidance form can be found. There is also a digital version of the guidance form. Permission needs to be granted from the ministry of Infrastructure and Environment to be allowed to use this version (Stichting vervoeradres, 2012).

For PostNL's operations, no guidance form is needed when transporting less than 500 kilograms of unharmful waste in one vehicle. This is an amount that will not be exceeded in the near future. In case it is exceeded, it means that for every small part of the chain, another guidance form is needed. For example, from the customer to the depot or from the depot to the delivery address, a separate guidance form is needed. In general, every time the parcel is transported with another vehicle, a

different guidance form is needed. This obviously involves significantly more information flows and paper work than when it does not exceed the maximum 500 kilograms of waste per vehicle. This can partly be tackled by using the digital guidance form and by standardizing parts of the guidance form. For the first vehicle, the consumer is the disposer when transporting the waste from the consumer to a depot. For this actor it would be impossible to fill in the guidance letter, since the consumer does not have sufficient knowledge and information to do so. Therefore, an exception position should be requested from the LMA by PostNL, suggesting PostNL to fill in this guidance letter instead of the consumer. This is the same as how it is organized when PostNL is a collector of e-waste (Stichting Vervoeradres, 2012; LMA, personal communication, October 10, 2013).

7.1.1.3. Reporting to the LMA

In most cases the receiver of waste has the responsibility to report to the LMA. This reporting consists of three things: the first acceptance of the waste, monthly acceptance of the waste and the release of the waste. The first acceptance of the waste consists of some general information regarding the waste and the actors involved. The monthly reporting of the waste concerns the amount of the waste based on the waste flow number. The waste flow number is a number received from the LMA, consisting of two parts: a part related to the transporter and a unique part linked to the specific flow of waste. The last reporting is done when releasing the waste to another party. When the receiver has the reporting responsibility they also need to provide the disposer with a waste flow number. In this case the waste, flow number also needs to be put on the guidance form when needed (Stichting vervoeradres, 2012).

Some exceptions are applicable to this network. First of all, there is no reporting responsibility for the receiver when receiving and releasing it, if the storage or transhipment location of the waste is equal or smaller than $50m^2$. Moreover, for this network most of the webshops already need to report the e-waste themselves, since they are obliged to do this under the producer responsibility. Since this network is executing the take-back for the webshops, no additional reporting needs to be done by other actors of this network than the webshop. As long as PostNL has a contract with the webshops to perform this kind of take-back system, PostNL and the possible partners within the network will fall outside the reporting responsibility (LMA, personal communication, October 10, 2013). However, the amount and the sort of e-waste received per webshops needs to be checked at the collection centre, since the webshops need this information for reporting under the producer responsibility. Moreover, the receiver of the e-waste needs to report to the municipality about the activities they are conducting on location. Since this is the same for both roles, more about this will be explained later (Stichting vervoeradres, 2012).

7.1.1.4. Keeping an administration for the LMA

All the parties handling waste need to have an administration of these activities. The administration should include what kind of waste is transported or handled, in what amounts, and from where to where the waste is transported. This data has to be kept for 5 years by each of the parties involved; these data are almost the same as is required for the guidance form. The disposer does not need to keep an administration of the waste (Stichting vervoeradres, 2012).

7.1.2. Collector

7.1.2.1. VIHB-list

First of all, the current status of PostNL being a transporter has to be changed to being a transporter and a collector. This is a relatively easy procedure, since an email needs to be sent to NIWO containing all the relevant data and the request to change the activities on the VIHB-list. Sometimes renewed documents are requested of items, such as the transportation license. After this, all the old documents with regards to the old registration need to be returned to NIWO, after which new documents will be received. The rest is the same as described for the transporter (NIWO, 2012) (Jansen, NIWO, Personal communication, August, 2013).

7.1.2.2. Guidance form (Begeleidingsbrief)

For the collector, mostly the same thing holds as for the transporter, which mainly means that for a small volume no guidance form is needed. For the part of the chain that involves transporting the waste from the webshop´s customer to the depot, no guidance form is needed also for bigger volumes. This waste is picked up from households but not considered as being collected yet; therefore it is still part of the households' waste for which no guidance form is needed. Herewith, the problem of the consumer having to fill in a guidance form is eliminated. For the rest of the chain, the collector has to fill in the guidance form instead of the disposer (Stichting vervoeradres, 2012; LMA, personal communication, October 10, 2013).

The collector of e-waste collects either under the route collection (route inzameling) or under the collection regulation (inzamelingsregeling). The route collection means that one collector collects the same type of waste from multiple pick-up addresses. This needs to be reported on the guidance form. Under the collection regulation the collector only collects waste from one pick-up address. The collection and transportation of e-waste is allowed to be done by using one waste flow number via the route collection (Stichting vervoeradres, 2012).

7.1.2.3. Reporting and registration of the waste to and for LMA

For the reporting and administration of waste, the same holds for the collector as explained for the transporter. The only difference is when the receiver has reporting responsibilities; the waste flow number needs to be given to the collector and not to the disposer. In this case, instead of the transporter keeping an administration of the waste, the collector has to keep the administration (Stichting vervoeradres, 2012).

7.1.3. Comparison

Table 9 provides an overview of the legislation.

	Transporter	Collector
VIHB-List	- PostNL is registered as transporter - Drivers sub-contractor also need to register as a transporter - Keep a certified copy of the VIHB registration in vehicle	**See transporter except for:** - PostNL needs to reregister as a collector
Guidance form	- For all vehicles the parcels pass during the distribution a separate guidance form is needed - It needs to be filled in by the disposer (causes problems for the first vehicle, picking up e-waste from customer) - When transporting < 500 kg of unhazardous waste not needed	**See transporter except for:** - It needs to be filled in by the collector - when collection with a route collection only one guidance form is needed
Reporting to LMA	- The receiver of waste has to do three kinds of reporting - Waste flow number needs to be given to disposer **Exemptions:** - If the storage or transhipment location of the waste ≤ 50m2. - When the e-waste is already reported under the producer responsibility	**See transporter except for:** Waste flow number needs to be given to collector
Administration for LMA	- All parties have to keep a waste administration for 5 years. For e-waste the disposer gets exemption	**See transporter**

Table 9 Overview of legislation per role

In general both roles require the same responsibilities and have mostly the same requirements. There are only a few differences worth mentioning. First of all, registering for the VIHB list is easier for the transporter, since PostNL is already registered as a transporter. Secondly, the issue of the consumer being a disposer when PostNL is a transporter is solved when PostNL is a collector. For the customer an exception position should be asked from the LMA by PostNL when being a transporter of waste. Therefore, it can be concluded that it is slightly easier to be a collector than a transporter.

Moreover, sometimes the line between being a transporter and a collector is a bit blurry. This mostly has to do with whether the ownership of the goods is transferred from the consumer first to PostNL or directly to the webshops. Therefore, to be on the safe side it is better to have the collector status. Also, as explained for the VIHB-list with the collector status, the actor is also allowed to transport e-waste but not the other way around.

7.1.4 Requirements for facilities

A facility that stores waste has to comply with additional legislation. The party storing the waste always has to comply with the activity decree (activiteitenbesluit) part of the environment

management (milieubeheer) and sometimes an environmental permit (omgevingsvergunning) is also required. When you have to comply with the activity decree it means you have to report the activities that in this case are related to waste, to the municipality where the facility is located (Province of Noord-Holland, personal communication, October 3, 2013).

An environmental permit is a permit required for all activities related to building on site, constructing buildings and all other activities that have a negative impact on the environment. When storing a maximum of 100m^3 of e-waste collected from the end holder under the new for old take-back legislation system an environmental permit is not required. In terms of pallets this refers to more than 100 pallets of e-waste, which is more than the amount expected to be present at the same time at a collection and/or sorting facility (Province of Noord-Holland, personal communication, October 3, 2013; Dutch Government, 2013).

Under the activity decree you are allowed to store and sort WEEE but you are not allowed to make changes or disassemble the equipment. It requires less work and time to comply with the activity decree than to comply with the environmental permit. Getting an environmental permit takes 6 months while the activity decree can be organized within a few weeks. For the activity decree only the specific activities that could have a small effect on the environment needs to be reported to the municipality, while for the environmental permit all the activities of the facility need to be assessed and reported. For this specific network it means that under the activity decree, activities executed related to waste at the facility and the type of waste need to be reported. When a facility has a major impact on the environment, an environmental permit is always needed (Province of Noord-Holland, personal communication, October 3, 2013).

In addition for facilities falling under the activity decree and the environmental permit, the maximum storage and maximum process capacity need to be registered. In case that the sorting is done by an external party, the receiver needs to provide a description of the acceptation and inspection procedure of the waste. Also, depending on the activities, an acoustic report and a report analysing the soil could be requested. Moreover, measures should be taken to prevent harm to the environment (Dutch Government, 2013).

For facilities already requiring the activity decree it is mostly easier to add another activity to their facility, since in most cases only the changes need to be reported. Therefore, an external facility, such as a sheltered workplace, that already reports their activities under the activity decree to the municipality is preferred. An external facility in general is also is preferred, since in that case PostNL does not need to report to the municipality themselves. After the sorting or collection facility acquired an activity decree inspections could be performed by the municipality to see whether the facility conducts its operations in accordance to the reported activities of the activity decree (Province of Noord-Holland, personal communication, October 3, 2013).

For the logistics network another point in regards to the environmental permit needs to be taken into account. When transporting waste or dangerous goods from one transportation vehicle to another, this is seen as transhipment and in that case you always need an environmental permit. This would mean that all the PostNL depots need such a permit. However, in that case this would also hold for

other operations of parcel distribution companies, since there could always be waste or dangerous goods in the parcels, without the knowledge of PostNL. Moreover, the government has stated that they will simplify some legislation in regards to environmental permit and the take-back of e-waste. Hence, the impact of the environmental permit could be smaller than originally expected.

Noticeable is that in regards to this permit the municipality is significantly stricter than the LMA. In regards to the LMA, these activities for small quantities of the waste are allowed to be done without any reporting to the LMA. A dialogue will be needed with the government and the municipalities in regards to whether all logistics service providers need such a permit for all their depots or whether an exemption could be made, when following all the other regulations (Province of Noord-Holland, personal communication, October 3, 2013). This research will not elaborate on this aspect, since the permit at depots goes beyond the e-waste topic.

7.1.1.1 Conclusion facility

In regards to the sorting facility being used it can be concluded that an external facility is preferred, since in that case PostNL does not have to execute all the different kinds of reporting. The easiest would be to use a facility that already has activities under the activity decree. In that case the reporting to the municipality and the complexity to comply with the legislation for the external facility will be minimal. The flow of the materials should make sure that there is no more than $50m^2$ or $100m^3$ of waste at the same time at the facility, since then the facility does not need to report to the LMA and no environmental permit is required.

7.2. In-depth external stakeholders analysis

In this analysis the points of view of the different stakeholders that were classified in chapter 5 as having a high influence on the reverse logistics network for e-waste from webshops' customers, are further investigated.

7.2.1 General stakeholder perspective on e-waste take back legislation

Atasu et al. (2012) wrote an article about the stakeholder perspective on e-waste take-back legislations. Two different models were discussed; a tax model and a take-back rate model. Three different decision makers were identified: consumers, manufacturers, and a social planner. An example of a social planner is the government. From this article it can be learned that the incentives for the different stakeholders can be misaligned mostly due to cost. The preferences based for the different systems for the manufacturers and consumers are mostly driven by costs. This sometimes misaligns with the perspective of the social planner. For example, a high take-back cost of the e-waste compared to landfill cost of e-waste, may result in e-waste ending up in landfills. It could also result in lower consumption instead of waste control. The different perspectives and misalignment between the different stakeholders are confirmed by the meetings with the stakeholders and other literature.

7.2.2. Webshops

Without webshops asking PostNL to collect the e-waste for them, this whole network would not exist or at least not in the same manner. In the literature there is not much written about this specific stakeholder in regards to the take-back legislation, since webshops having to comply with this

legislation has only recently become a relevant topic. However, webshops are classified as a distributor and/or producer and therefore the "producer responsibility" mostly affects them. Hence, both the distributor and producer have a financial responsibility towards collecting e-waste. Since distributors have to offer a take-back opportunity for the customers free of charge, they have financial obligations for the collection and transportation of e-waste. The responsibility of producers includes financing the treatment, recovery, recycling and environmentally sound disposal of WEEE (Ongondo, Williams, & Cherrett, 2011).

Webshops can decide themselves how to take this responsibility; either by offering a collecting possibility themselves or by outsourcing it to a third-party. After the second warning letter of the Ministry of Environment and Infrastructure, several webshops contacted PostNL to see what kind of possibilities PostNL offers. From these conversations could be learned that webshops mostly like to collect e-value themselves, since money can be earned with this stream. In order to collect the e-value some webshops acquire a reply mail number that corresponds with their own DC or with an external facility. In that way PostNL could be the transporter of e-value. This system could also be used for e-waste, but is only considered when the collection and sorting of e-waste can be executed by the webshops or one of their partners for a sufficiently lower cost.

Mostly, due to the low value of the e-waste, webshops do not want to collect the e-waste themselves and therefore they ask PostNL to collect the stream of e-waste. When PostNL collects the e-waste it is done in a collective system, therefore PostNL need to assure a proper registration system for the webshops (Project manager proposition e-waste, personal communication, September 10, 2013).

The needs of the webshops have a major effect on the network. One of these effects is related to the motivation why webshops want to offer a possibility for the e-waste stream. Since their driver is legislation driven this led to webshops stating that they will not promote this extra service widely, since it only costs them money. Evidence of this can be found on the websites of some of the webshops already offering this service. The webpage about this service can mostly only be found when specifically searching for this service and does not have a prominent place on their websites. A bigger volume of e-waste returns would mean an increase in total cost related to taking back the e-waste for the webshops. Therefore, a webshop will only start to promote this take-back program when they are not affected negatively by the costs of collecting a higher volume, or when webshops need to reach a collection target themselves. This preference for limited volumes conflicts with the preference of most of the other stakeholders, since the other stakeholders prefer a high volume (Project manager proposition e-waste, personal communication, September 10, 2013).

Thus, for webshops the best network solution would be the one with the lowest cost possible, which equals the lowest possible number of returns and would be a network that does not involve them collecting the e-waste themselves unless it is significantly cheaper to perform the activities themselves.

7.2.3. Customer

Without a customer returning their e-waste to the PostNL driver there will not be any volume in this recycling program/reverse logistics network. As stated in the survey conducted by an intern at

PostNL for this specific program, an end user needs to provide the old equipment with packaging and a reply mail number with an address as stated on the website. The average willingness of the respondents to participate in this recycling program was 65% without receiving any payment or incentive in return (Vroom, 2013). This high percentage could be explained by the fact that the proximity from the household to the collection point is as low as it could possibly be, since it is picked up at their homes. The proximity of recycling containers is recognized to influence the recycling behaviour (Ludwig, Gray, & Rowell, 1998); (Margai, 1997).

This is related to the fact that customers are more willing to participate when they have to put in as little as effort as possible. For example, people were less willing to participate when they first had to pick up a box at a post office. Hence, it should be taken into account that the less effort the customer needs to do in order to participate in the recycling program, the more they are willing to participate (Vroom, 2013). In many articles this can be confirmed, since often it is stated that the personal convenience of recycling influences people's recycling behaviour. (De Young, 1988-1989) (Vining & Ebreo, 1990) (Vining, Linn, & Burdge, 1992).

Further, the respondents that already recycle are more willing to participate in this system. The survey also investigated whether the respondents are willing to pay for recycling e-waste. It was found that people already recycling are more willing to pay (Vroom, 2013). However, in legislation it is stated that it must be done free of charge, so the customer cannot be charged for participating in this specific program (European Commission-WEEE Directive, 2003). This legislation has a major influence on the possible financial structures, since it eliminates the possibility to let the customer pay for this recycling system. A financial incentive on the other hand could be given to a customer to motivate them to participate in the program.

Finally, according to the survey 44% of the respondents had already heard about the take-back legislation. This is quite a high percentage. Therefore, the customer should be informed on the website of the webshop about this specific recycling program and about the activities the customer needs to execute in order to give back the e-waste to the driver. Ideally this could be done by providing this information in a pop-up on the webpage, when a customer is ordering the electronic equipment online (Vroom, 2013).

So, in order to have a lot of customers returning their e-waste, it should be made as convenient as possible and be done without any cost. Other financial incentives might be offered to increase return volumes.

7.2.4. Sub-contractor drivers

The driver is an important player in the chain, since they have direct contact with the customers and they build up some customer relationships with them. This customer relationship is not only based on delivering the parcels on time but also on the politeness and friendliness of the driver. Moreover, the driver is the employee that communicates with the customer the most, more than a sales person, while drivers are mostly not trained to communicate with the customers (Moon & Fitzgerald, 1996).

In the stakeholder analysis was stated that the sub-contractors have a low interest in new services, this assumption was confirmed during the conversation with the drivers. The sub-contractors were informed about a bulletin posted on a wall of a depot, explaining a new service with regards to spontaneous returns. When asking multiple drivers, only a few knew the procedure. This could be because the service is not requested a lot but maybe also since they do not feel sufficiently (financially) triggered to offer the service (PostNL driver, personal communication, August 18, 2013). Although, it can also be argued that the instruction of a new service could be better communicated.

This relates to the fact that the most important incentive for the sub-contractor drivers is a financial one. Sub-contractor drivers get paid per parcel being delivered and are thus in general more willing to work harder to deliver all their parcels. On the other hand, a PostNL driver receives the same amount irrespective of the amount of parcels being delivered. However, the system of getting paid per parcel delivered may also have some negative side effects. For example, this may result in parcels being handed over to the neighbours when this is not allowed as requested by the sender of the parcels. Or it might result in sub-contractors writing a signature themselves and for example putting it in a mailbox (PostNL driver, personal communication, August 18, 2013). Multiple complaints forums of different parcel delivery companies give examples of these negative side effects.

Using a single financial indicator to monitor performance and to link someone's pay to, can result in dysfunctional behaviour (Moon & Fitzgerald, 1996). So in order to make the sub-contractor interested in offering the extra service of returning e-waste there should be an economic driver but also some other incentives in order to have a high customer satisfaction.

Both incentives fall outside the scope of this research. The financial incentive falls outside the scope of the research, since the extra service the driver conducts for the e-waste is categorized as a (spontaneous) return. This means that PostNL should think of an adequate financial compensation for the whole (spontaneous) return service. The motivator of the sub-contractor drivers is a completely different topic of research.

Furthermore, in regards to the practical restrictions, the driver should not perform many extra or difficult activities. If this is the case, however, the drivers should be instructed well about this new service and the activities it requires them to execute.

7.2.5. Sorting centre

Many facilities are suitable as sorting centres to a certain extent. For the receiving, unpacking and sorting of e-waste, a facility mostly needs to have space available to store the e-waste and to perform these activities. Whether other activities such as testing and repairing can be performed depends on the facility. In this research two possible sorting centres were assessed; a fulfilment company that is a subsidiary of PostNL and a sheltered workplace that is an existing partner of PostNL. In general PostNL prefers the fulfilment company to execute this extra service, due to the fact that it is PostNL's subsidiary. However, the sheltered workplace offers a more extensive kind of sorting than the fulfilment company and is also able to test and resell the working e-waste from a

thrift shop on location. Repairing activities are possible at the sheltered workplace, since they currently do this for some products, such as scooters for elderly people. These are valuable products and are mostly a homogeneous stream. E-waste on the other hand consists of low value products and the stream is very heterogeneous in terms of products types, brands and specifications. This complicates the stream enormously and therefore repairing e-waste is not economically viable yet, especially for a low volume (Sorting centre 1, personal communication, August 26, 2013; Sorting centre 2, personal communication, September 20, 2013).

Figure 11 Lansink's ladder

Whether the e-waste is sorted and whether the sorting facility can also test and repair, affects the final destination of the network and the financial structure. The activities executed in regards to the e-waste could result in different possible gains and cost for the network. According to the Lansink's ladder reuse is preferred over recycling (see figure 11), since some products can easily be used again without having to perform many activities (mostly only checking, cleaning and some repairing). However, sometimes it needs to be analysed whether reuse is preferred by looking at how sustainable the design is, the effects of wear and tear of the design, the cost of reusing it, the possibilities to reuse components and the value of recycling the material (Lansink & in 't Veld, 2010). Especially the costs need to be analysed before deciding whether reusing or recycling is better.

In terms of financial structure, both possible sorting centres have the same system. The different activities need to be paid based on the time an employee spends on the different activities and the other component is the amount paid for the storing of the e-waste which is done per pallet place per week.

From the two meetings with the sorting centres could be concluded that when the existing facilities would conduct these activities they want to have a high volume of e-waste. As explained in the legislation section of this chapter, the sorting centre has to comply with quite some legislation. In order for them to pay off, some volumes need to be reached. Moreover, the two possible sorting centres identified for this network are both very flexible in the adaptions to the new service and are therefore willing to fit the requirements (Sorting centre 1, personal communication, August 26, 2013; Sorting centre 2, personal communication, September 20, 2013).

As mentioned before, in the network there could be more than one sorting centre. The main reason would be that the location of the testing and grading has a major influence on the flow of goods. Only after this process the products can be assigned to reusing or recycling and to a geographical area. However, since the network is currently being designed for a small country and a small volume only one sorting facility should be used. In case the volumes increase majorly and the reduction in transportation cost offsets the decrease in facility cost a sorting system per region could be assigned.

7.2.6. Recycling company

There are a few recyclers in the Netherlands that recycle electronics. The main factor the recyclers compete on is the price they offer for the e-waste. Other ways to compete are the recycling percentage of the recycler and the way the e-waste is reported, since this is an important factor asked for by the government (Recycler 1, personal communication, August 6, 2013; Recycler 2, personal communication, October 14, 2013).

These latter two are also identified as important factors by the market (Brand, 2013). Last, recyclers that can offer extra services such as a lab checking the quality of the e-waste streams is also an advantage, since it makes a recycler more reliable and therefore more suited for cooperation in the long run.

Both recyclers emphasized that they would like to have large volumes. This is also the reason why only one recycler is considered and not separate ones per region or material stream. Only when there is sufficient volume to use multiple recyclers this aspect becomes relevant. The large volumes of e-waste are mostly not sorted beforehand into different streams but are put in a shredder all together. Then the materials are separated by machines. Some recyclers also pay a higher amount for the e-waste when being sorted in advance into different streams. The prices recyclers are willing to pay for the e-waste are based on the market price of the materials, based on many external factors. Therefore, in terms of financial structure it is difficult for recyclers to set a fee they will pay to PostNL or webshops for the e-waste (Recycler 1, personal communication, August 6, 2013). Also the interest of the recycling company for the materials changes when the market price for the material is rather low. The focus is mostly on the equipment with the highest value. This is also the reason why many recyclers would like to have the e-value stream, because of the profitable materials (Brand, 2013).

In regards to the network, direct transportation can also be eliminated as a possible option from the perspective from the reprocessing facility. The recyclers do not want to receive the e-waste in parcels, since this means it first has to be brought to a place where it is unpacked. Also, the parcels should be unloaded from the truck instead of just receiving a container full of waste. Since this means that the e-waste needs to be unpacked first at a collection centre, it is logical to execute the possible sorting at the collection centre instead of doing that at the recycler (Recycler 1, personal communication, August 6, 2013; Recycler 2, personal communication, October 14, 2013).

7.2.7. Government

Due to the European WEEE legislation it is not surprising that the government wants to collect e-waste conform the set targets in the European legislation as discussed before. Therefore, the government has a role in informing people about this legislation and the importance of recycling. Moreover, other developments in regards to sustainability and recycling are currently happening in the Netherlands. The government recognises the importance and has announced the program “van afval naar grondstof” (from waste to resources) after the latest Prinsjesdag on the 17th of September 2013. This program highlights the increase in the use of materials and wants to emphasize the importance to shift to a circular economy. In addition, the government wants to simplify receiving

the environmental permit, since now some permits and legislations result in major practical implications (Rijksoverheid , 2013).

The importance to shift to a circular economy is also emphasized in recently published reports. The Dutch Planning council for the environment (Planbureau voor de leefomgeving) published "Vergoenen en verdienen" (Greening and earning) (Raad voor de leefomgeving en infrastructuur, 2013) and the council for environment and infrastructure (Raad van leefomgeving en infrastructuur) released the report "Designed to last" (Planbureau voor de leefomgeving, 2013). These organizations are two advising bodies to the Dutch government in regards to the environment and the latter one also for infrastructure. Therefore, the importance of a circular economy is expected to become stronger for the coming years.

Furthermore, based on the letters the government sent to webshops, it can be concluded that the government is becoming stricter on whether webshops offer a take-back possibility to their customers for the e-waste. In this way more e-waste will be collected and the same is being asked from webshops as from the retailers using traditional distribution channels. This part of the law enforcement is executed by the Ministry of Environment and Infrastructure. The controlling of the waste transportation and the facilities is executed by the LMA and municipalities.

7.2.8. Elimination of the network based on the stakeholder analysis

Table 10 gives an overview of this section in regards to the perspective of the stakeholders which are classified into returns volume, financial structure, network structure and information flow, since these were the topics mostly addressed in the description above. PostNL's perspective is also added to the table, so the points of view of the other stakeholders can be compared with PostNL's point of view.

Based on the stakeholder analysis some network options can be completely eliminated, since this is not feasible for one or more of the stakeholders. The impacts on the information flow and financial structure of the stakeholders have been addressed in chapter 6.

Repairing e-waste can be eliminated as an activity executed at the sorting centres. The fulfilment company does not have the possibility to repair at their facility, hence the activity is eliminated. Repairing activities are currently not economically viable and therefore it is also eliminated as a possible activity at the sheltered workplace.

Due to the preference of the recyclers the network options considering directly transporting the parcels to a recycler can be eliminated. The recyclers do not want the e-waste arriving in parcels and therefore this network is not feasible. Moreover, some recyclers offer a higher amount for the sorted material. In that case the e-waste has to pass a sorting facility first and is therefore not transported directly to a recycler.

Based on the volume, the network with multiple sorting centres and recyclers can be eliminated. These two stakeholders pointed out that they would like to have large volumes.

	Return volumes	Financial structure	Network Structure	Information flow
Webshops	Low volume, a high volume means higher cost.	Lowest cost possible	- Prefer not to collect e-waste themselves, unless it is sufficiently cheaper to perform this themselves - Financially and operationally responsible	- Want to inform their customer as little as possible about the possibilities. - Request a proper registration system from PostNL
Customer	Indifferent	- Customer is not allowed by law to pay for the disposal of e-waste. - Might get financial compensation from webshop for participating in the program	Giving back the e-waste must be as convenient as possible	Should be informed about conditions of the take-back program
Sub-contractor driver	Low, unless they have a sufficient financial incentive	Want to be financially compensated (outside scope)	As little extra handling as possible	Being well-instructed for the service
Sorting centre	High and consistent volumes	Want to get paid per activity in terms of hourly wage of the employees + pallet place per week	- Different service of the sorting centre result in different end destination of e-waste - Due to volume one sorting centre per network	See legislation chapter
Recycling company	High and consistent volumes, preferable high-value waste	Their offered rate fluctuates since it is based on market prices	- Do not want to receive it in boxes, meaning it has to pass a collection centre - Due to volume one recycler per network	See legislation chapter
Government	High properly disposed volumes	Webshops are financially responsible	Legislation has impact on the processes, might become more flexible	Informing role to webshops and other parties in the Netherlands (citizens)
PostNL	High volumes for economies of scale	Receive a small margin	Transportation is being done in a closed box with a reply address	Inform the other stakeholders about the services

Table 10 Perspective of the stakeholders on the supply chain configuration and management and on the Volume.

7.3. Competitors analysis

The competitors were not seen as a stakeholder influencing the take-back service and PostNL does not have an interest in keeping them informed, however lessons could be learned from the take-back services competitors are offering.

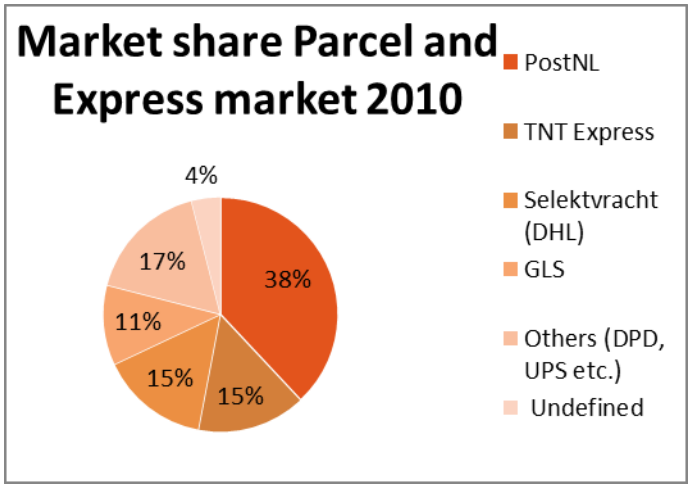

Figure 12 Market share parcel and express market 2010 (OPTA, 2010)

As stated in the methodology, simply looking at the market share of the parcel delivery companies in figure 12 is not sufficient to conclude that there is no other solution in the market yet. Therefore the websites of the webshops registered on thuiswinkel.org that deliver their parcels by another parcel delivery company than PostNL were assessed. From all those webshops there was only one webshop offering a solution. This webshop is Wehkamp, in cooperation with Selektvracht.

Wehkamp's requirements to take back the e-waste at the moment of delivering are: the e-waste must be properly packed either in box or in a plastic bag that can be closed and does not tear, the equipment must be empty and clean, so no oils and liquids can be inside and loose parts must be attached and properly wrapped so they cannot damage any of the other products in the vehicle. Moreover, Wehkamp assures that the equipment is processed in an environmental friendly way in line with legislation (Wehkamp, 2013).

These are comparable requirements to those of PostNL. Differences are that the customer has to state online when ordering a new product that it wants to give back an old product. It seems that a customer cannot give back their e-waste by means of a spontaneous return, as is the case at PostNL. Another difference is that for Wehkamp the customer does not have to provide the e-waste packaging with a reply number. This raises some questions as to where Selektvracht will bring the e-waste and whether this is done through their parcel delivery network. In terms of the guidance form and the reporting it will be the same as for PostNL. Last, Selektvracht also needs to be registered on the VIHB-list. Currently, Selektvracht is not registered on the VIHB-list, but its mother company DHL is registered as a transporter. It is questionable whether this is sufficient (NIWO, 2013).

In conclusion, most parcel delivery companies do not offer to take-back the e-waste at the moment of delivery as a service to their webshops. From Selektvracht can be learned that they require the end user to execute less procedures, which makes it more convenient for them to give back the e-waste. Their network structure(s) and operations are not clear and therefore lessons cannot be learnt from this.

8. Performance

The last elimination of the networks is based on the performance. As stated in the conceptual model and the methodology, the performance of the networks is determined by the cost and benefits of each network. For this specific take back network of e-waste from the customers of webshops, the gains from the materials cannot cover the costs of the networks. Therefore, the key is to minimize the difference between cost and the gains of the entire network, since the webshops would like to pay the lowest possible price for this legislation driven service. For PostNL the network with the lowest cost per parcel is also important, since this could result in a higher volume than for the networks with a higher cost per parcel. PostNL gains money from a margin per parcel and therefore volume is important.

8.1. Overview of the calculations of the different costs per cost cluster

At this stage only a few network options are left. For the variations in means of collection two options are left: the sub-contractor collecting the e-waste from the customer when delivering new equipment and the customer bringing their e-waste to a post office when collecting their new EEE from the post office. All the variations regarding the depots have been eliminated in chapter 6. For the variations regarding the collection centre, using multiple collection centres was eliminated together with the option to repair the e-waste. All the other activities are still possible options. For the reprocessing facility variations, the options using multiple facilities have also been killed at a gate, due to the volume. The variations of reusing and/or recycling have not been eliminated. Regarding PostNL solely being a transporter, the option of directly transporting to a reprocessing facility was eliminated.

For the network options and variations left, the comparison is made between a sheltered workplace and a fulfilment company, resulting in six different options for PostNL as a collector. Together with one options for PostNL being a transporter, this resulted in seven options in total. Table 11 explains the seven options for which a costs and gains analysis was executed based on the above mentioned formulas.

	Sorting facilities	Activities
Option 1	Sheltered workplace	- Transportation from customer to sheltered work place - Basic handlings at SW (registration, unpacking, internal transportation and handling and storage cost) - Transport to recycler - Gains from e-waste
Option 2	Sheltered workplace	- Same as option 1; only sorting of e-waste added - Gains of e-waste might change
Option 3	Sheltered workplace	- Same as option 2; only plug test is added - Gain from resalable equipment in a thrift shop added
Option 4	Fulfilment company	- Same as option 1 only the transportation is from the customer to the fulfilment company - All handlings are executed at the fulfilment company
Option 5	Fulfilment company	- Same as option 4 only sorting is added - Gains of e-waste might change
Option 6	Sheltered workplace	- Same as option 1 only the e-waste is not collected from the customer but brought to a post office, from which it will be transported to a depot.
Option 7	DC webshop	Transportation via the PostNL parcel distribution from a customer to a reply address of a webshop

Table 11 Different network options left in the performance chapter

The cost and benefits of the performance are divided into a few clusters, which are more or less the same as described in the literature and some of the cost are also inspired by literature. Each cluster is briefly discussed, explaining how the costs were calculated in the excel model.

8.1.1. Cluster 1 PostNL's parcel distribution

The first cost of the PostNL's parcel distribution is the collection cost (CC) of the parcels of e-waste. For the first five networks, this means that the driver collects the e-waste from the customer when transferring a new product to the customer of the webshop. This collection cost also includes the sub-contractor driver bringing the e-waste to the closest depot. The cost per parcel does not change when the volume increases.

The distribution cost from depot to depot (DCDD) is based on the average cost of transporting a parcel from one depot to another depot. This cost varies depending on from which depot to which depot the parcel is sent. Since the parcel could be sent from everywhere in the Netherlands, an average was calculated from a representative depot. The cost also includes all the costs made at depots including depreciation, administration and wage costs. This cost is translated into a constant cost per parcel.

The delivery of the e-waste from the last depot to the sheltered workplace consists of a fixed fee for delivering on an address and a variable fee for the amount of parcels being delivered.

The average cost of one parcel when delivering parcels to a delivery address:

$$\frac{(\text{Fixed fee} + (\text{Amount of parcels} - 1) * \text{Variable fee})}{\text{Amount of parcels}}$$

For this model, it is assumed that the sorting facilities are open 5 days per week and therefore the delivery can only be done on those 5 days. Since the volumes are calculated in weeks they need to be divided by 5 to get the amount of parcels per day.

The delivery of the e-waste from the last depot to the fulfilment company consists of a constant cost per parcel (DCFC). These parcels are added to a truck that is already driving from the last depot to the fulfilment company and therefore a fixed amount per extra parcel is charged. This constant cost is about the same amount as the delivery cost per parcel to the sheltered workplace for a volume of 100 parcels per week.

The total cost per parcel of the PostNL parcel distribution network with CC:

$$\text{CC} + \text{DCDD} + \frac{(\text{fixed fee} + (\text{amount of parcels per day} - 1) * \text{variable fee})}{\text{amount of parcels per day}} \quad or \quad \text{CC} + \text{DCDD} + \text{DCFC}$$

For the sixth network option there is variation on the collection side. The parcel is not being collected from the customer by a sub-contractor driver when transferring the new product but instead the e-waste is brought to a post office by a customer of a webshop when collecting the new product. This cost consists of a fee paid to the post office and the transportation costs of the parcel to a depot. This together is a variable cost at the collection side using a post office (POC).

The total cost per parcel of PostNL parcel distribution network with POC:

$$\text{POC} + \text{DCDD} + \frac{(\text{fixed fee} + (\text{amount of parcels} - 1) * \text{variable fee})}{\text{amount of parcels}}$$

8.1.2. Cluster 2 costs at the facility

Activities	Total amount of minutes per pallet	Minutes per parcel (average)
Handling and registration	102	6
Internal transportation to department	4	0.235
Unpacking	3	0.176
Plug test	36	2.118
Sorting per product group	2	0.182

Table 12 Output pilot handling time different activities

Material	Amount
Total parcels	17
Total parcels in kg	120.9
Average kg per parcel	7.1
Total carton in kg	17.5
Average carton per parcel in kg	1.029
Total e-waste in kg	103.4
Average e-waste per parcel in kg	6.082

Table 13 Output: the amounts of the materials

All the costs of the different activities are all based on the output from the pilot at the sheltered workplace. Tables 12 and 13 contain some information from the pilot.

First everything was being recalculated from hours to minutes and to a cost per parcel.

$$Time\ activity\ per\ parcel\ (in\ minutes) = \frac{\text{Total amount of time spent for activity x}}{\text{Amount of parcels pilot}}$$

$$Cost\ per\ minute = \frac{\text{Labour cost per hour}}{60}$$

$$Cost\ per\ activity = \text{Time activity per parcel} * \text{cost per minute}$$

In this way the cost per parcel for all the activities was calculated. More specifically, registration and handling costs (RHC), the unpacking cost (UC) and the internal transportation costs (ICT) were calculated. If sorting (SC) and testing (TT) is being executed at a facility, the cost is calculated in the same way.

The storage cost is calculated differently. Per pallet place around 20 parcels can be stored.

The amount of *pallets places needed:* $= \frac{\text{Amount of parcels per week}}{20}$

The outcome should be rounded up, as two pallet places are needed for 21 parcels.

The storage cost per parcel $= \frac{\text{Pallets places needed per week} * \text{Storage cost per week}}{\text{Amount of parcels per week}}$

Total cost at the sorting facilities per parcel per week =

RHC+UC+ICT+ $\frac{\text{Pallets places needed per week} * \text{Storage cost per week}}{\text{Amount of parcels per week}}$ and sometimes + SC +TT

8.1.3. Cluster 3 transportation cost to facility

A recycler pays a fixed fee per kilo of e-waste.

The transportation cost per parcel =

$\frac{\text{Total weight e-waste pilot}}{\text{Amount of parcels pilot}} *$ Transportation fee per kg

8.1.4. Cluster 4 the gains from the materials

Gains from carton per parcel (GC) $= \frac{\text{Total weight carton pilot}}{\text{Amount of parcels pilot}} * \frac{\text{Fee per ton of carton}}{1000}$

Gains from e-waste per parcel (GEP) =

$\frac{\text{Total weight e-waste pilot}}{\text{Amount of parcels pilot (APP)}} * \frac{\text{Average fee e-waste per ton}}{1000}$

The gains from resalable equipment (GRE) = Average price by sheltered workplace

The resalable equipment is not equal to the amount of equipment that passed the plug test. When conducting the pilot, an overview of the type of equipment was also noted down. It cannot be guaranteed that all equipment is working based on a plug test for all equipment. In the pilot, printers

and vacuum cleaners passed the test. Based on this test it cannot be guaranteed that the printers actually work and therefore they were added to the total amount of e-waste. However, based on the plug test there is a significant chance that the vacuum cleaners are resalable.

To calculate the total gains, the proportion of the total of the amount of e-waste that will be reused and the proportion of the total of the amount of e-waste that will be recycled need to be multiplied with the amount of the gains, in order to calculate the total amount of gains.

$$Total\ \ amount\ \ of\ \ gains\ = \text{GC} + \frac{\text{APP}-\text{amount of resalable equipment(ARE)}}{\text{APP}} * GEP + \frac{ARE}{APP} * \text{GRE}$$

For all the options the total cost of the network minus gains of the network was calculated. The lower the amount of net cost left, the better the option performs.

8.2. The performance analysis

The actual costs of the networks are not displayed due to confidentiality of the different parties. Therefore, the numbers are displayed in relative numbers in relation to a base scenario rather than displaying the absolute number. The collection of the e-waste at the sheltered workplace without conducting extra activities such as sorting and testing was used as the base scenario with a volume of 1 parcel per week. This is selected as the base scenario, since this was the situation when the pilot was conducted. Compared to that scenario the percentage changes were calculated for all the other options and volumes. This resulted in table 14 and figure 13.

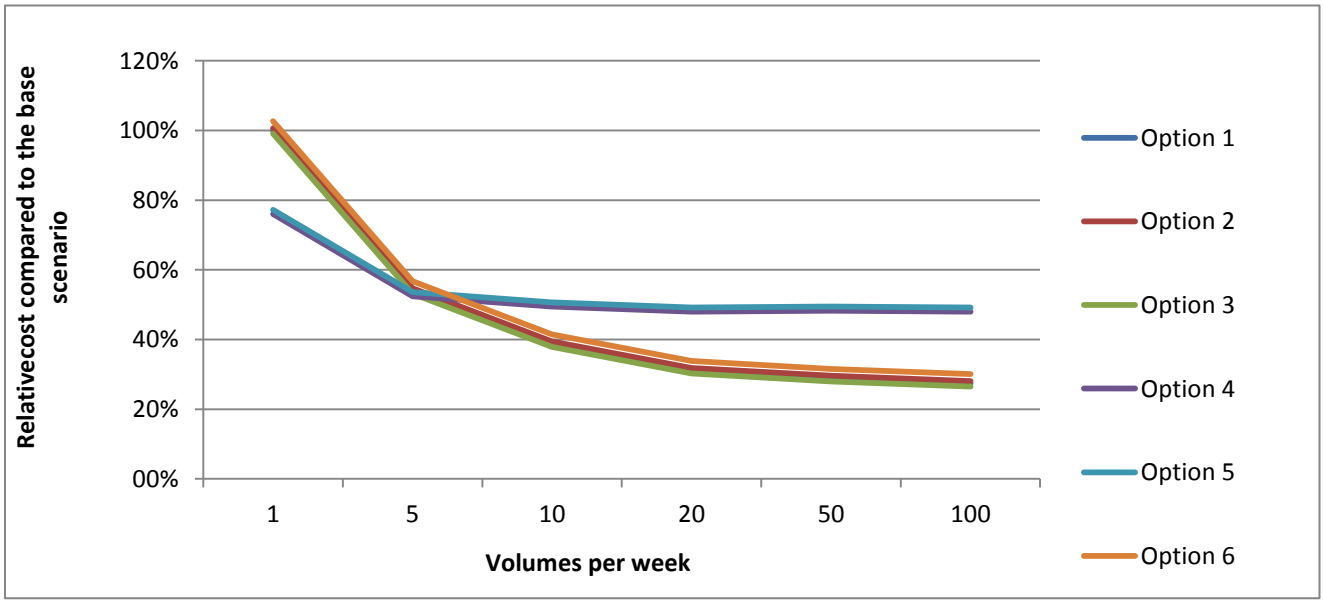

Figure 13 The overall cost of the network options

	Volume per week					
	1	5	10	20	50	100
Option 1	100%	54.1%	38.9%	31.2%	29.0%	27.4%
Option 2	100.6%	54.7%	39.5%	31.9%	29.6%	28.1%
Option 3	99.0%	53.1%	37.9%	30.3%	28.0%	26.5%
Option 4	76.0%	52.4%	49.4%	48.0%	48.3%	48.0%
Option 5	77.2%	53.6%	50.7%	49.2%	49.5%	49.2%
Option 6	102.6%	56.7%	41.5%	33.9%	31.6%	30.0%

Table 14 The overall cost of the network options

In table 14 and figure 13 it can be seen that in the beginning the options using the fulfilment company are the cheapest. This has to do with the fact that the storage cost of a pallet place at the fulfilment company is almost half the price of a pallet place at the sheltered workplace. When a pallet place is fully utilised it will be divided by 20 parcels and the cost of the pallet place will only be a minor part of the total cost. Therefore, for bigger volumes the variable cost of the activities has a larger impact. This is due to the fact that the wage of an employee at the fulfilment company is almost twice the cost of an employee at the sheltered workplace. Therefore, the activities executed at the fulfilment company are twice as expensive as at the sheltered workplace.

The minor effect of the storage cost on the bigger volumes can be seen in option 4 and 5. The percentages at a volume of 50 parcels per week are slightly higher than for the volumes of 20 and 100 parcels per week. This effect is not visible for option 1, 2 and 3, since for those options the changes in the transportation cost from the last depot to the sheltered workplace have a larger impact. This cost is the same per parcel irrespective of the volumes for the options of the fulfilment company, explaining the visibility of this cost in option 4 and 5.

Another interesting observation is that option 2 is more expensive than option 1 and option 5 is more expensive than option 4, while the only difference is that sorting is added to the network. This means that the extra cost that is added by sorting the e-waste outweighs extra gains that can be attained by executing this extra activity. This is solely because recyclers are not offering a significantly better price for sorted material compared to unsorted material.

When it is possible to also conduct a plug test at a facility, then the e-waste should be sorted for the purpose of executing the plug test, rather than offering it separately to a recycler. In option 3 the extra costs of sorting and testing are offset by the extra gains from the resalable material. For the fulfilment company option 4 (which is excluding sorting) is preferred. The fulfilment company does not have an option including testing, since this activity is not possible at that facility. Moreover, it does not have a thrift shop at its locations, which means that the resalable equipment has to be transported to another location in order to sell it, making this stream more expensive.

Moreover, the cost of collecting the e-waste at a post office and bringing it to a depot is higher than the cost of the driver collecting the e-waste directly from the customer. In the table it could be

observed that option 6 is more expensive than option 1 for all volumes, which is solely related to the difference at the collection side.

In table 14, only being a transporter of e-waste is not compared with the rest. This has to do with the fact that in this case a webshop can execute the collecting and sorting activities for a lower cost than in PostNL's network. When that is the case, that option is preferred, since it gives the lowest cost of the whole chain. PostNL will still get their margin for transporting the e-waste without having to execute the other activities. However, in order to attain high volumes in one network it would be better to have one solution, which mostly results in a lower cost. The option of PostNL only being a transporter could co-exist to one of the other options, in case there is a difference in what network the different webshops prefer.

8.3. Conclusion

In conclusion, when receiving more than 1 parcel of e-waste per day the sheltered workplace is preferred over the fulfilment company, which is mostly caused by the difference in hourly wages of the employees of the two facilities. Moreover, sorting should only be done if the equipment is also tested, so the gains from the resalable equipment offset the extra cost. Hence, the preferred network is the network at a sheltered workplace where all the activities are executed including the testing of the e-waste. Moreover, at the collection side it is preferred to have the sub-contractor collect the parcel from the customer over collection at a post office. However, the customers should still be able to give their e-waste to the post office when collecting their new EEE, so these options will need to co-exist. Last, when a webshop can execute the collection and the other activities for a lower cost than PostNL, then that option is preferred in terms of cost. This latter option could co-exist to the preferred option of the sheltered workplace.

9. Discussion

9.1. Conclusion

Before answering the main research question: *What is the optimal supply chain network, set up by PostNL in order to return e-waste from the webshops' customer, so that webshops can comply with the take-back legislation?*, the different sub-questions are answered first.

What role should PostNL play in the return process of e-waste from the webshops' customers and what should be the role of the other players/stakeholders?

In order to answer this question the roles identified on the VIHB-list were used, since these are the only licensed roles PostNL could have. From this analysis it became evident that the only possible roles PostNL could have are solely being a transporter of the e-waste or also being a collector of e-waste. Being a mediator or a trader were excluded, since these roles do not allow the actor to have physical possession of the e-waste.

In the stakeholder analysis, the stakeholders that were ranked as having a high influence on the service and network were mostly the players handling the physical parcel distribution or the facilitator or controlling body of the network. The facilitators of the network are the webshops and PostNL's head office. The webshops are a facilitator, since without this actor the service would not exist. PostNL head office is also a facilitator, since on the request of the webshops they decided to provide a service for the webshops, which involved setting up this network.

There are also some actors in the network that physically execute this take-back legislation network. The consumer disposes of the parcel and gives it to the sub-contractor driver or post office. Then the internal parcel distribution, mostly being executed by the depots and the drivers of the trucks between the depots, execute the transportation of the parcel from depot to depot. Another sub-contractor driver delivers the parcel at the delivery address, which is the sorting facility. From the sorting centre the waste is transported to the reprocessing facility, which ensures proper disposal of the e-waste.

The last stakeholder is the controlling body, which is the government. The specific controlling bodies for this network are the municipality and the LMA. Whether the webshops offer a take-back solution for the e-waste of their customers is controlled and monitored by the Ministry of Infrastructure and Environment.

What are the possible supply chain networks that PostNL could implement for the return processes of e-waste?

In total 14 options (including the base model) were identified for PostNL when it takes the role of collector. The base model was designed based on the network in response to environmental take-back legislation as described by Fleischman (2001). The other options are all variations to the base model on the collection side, at the depots, at the collection centre and at the reprocessing facility. Two options were found for PostNL when taking the role of transporter. The options differ based on

to which destination the e-waste is transported by PostNL. The destination of the e-waste affects the overall network, in this case coordinated by the webshops.

What is the optimal financial structure for the supply chain network?

For the whole network it would be best if the webshops do not have to pay for all the activities in the network, since this restricts the volume passing the network. All the parties conducting the physical handling of the network would like to get a compensation covering their costs and prefer to have high volumes. The higher the volume, the more they can earn in total for their activities executed in the network.

The current network involves the webshops paying for all the activities in the chain. In case the e-waste is transferred to Wecycle, they pay for the transportation to the recycler and a price is paid for the disposed e-waste. In case another recycler pays a higher price also covering transportation, then that is the preferred financial structure.

Obviously, an external party paying for a part of the network, such as the NVMP or the municipality, is the best financial structure for all parties in the network, but further research needs to be conducted for this.

Which information flows are needed for the supply chain network in order to work well?

In order for the network to function optimally many information flows are needed. First of all, a lot of information needs to be exchanged between the actors executing the physical parcel distribution. It makes sure that it is known where in the network the parcels are situated and which actor needs to get paid for the executed activities.

Additionally, the information flows between the actors of the physical parcel distribution and the facilitators and between the different facilitators are important. Webshops have to inform PostNL about the service they would like to have and PostNL has to inform the actors in the physical parcel distribution about the new service and the activities the service implies, in order to make the network function optimally. The other actors also have to report to PostNL concerning the activities they conducted, since PostNL has the coordinating role in the supply chain.

Finally, the controlling bodies need to be informed about the activities in regards to waste. This information flow is mostly one-way and is done in terms of reporting the activities to the controlling bodies. The LMA and the municipality monitor the activities.

When PostNL is a transporter instead of a collector then some information flows that in the current model are directed to PostNL, go directly to the webshop. In that case the webshop is the collector and therefore has the coordinating role.

What is the impact of legislation on the different supply chain networks?

The different legislations complicate the activities of the different networks and result in more activities that need to be executed besides the physical handling of the parcels. Some administration requirements need to be met before starting the actual operations in the take-back legislation

network. These are the registration on the VIHB-list and reporting the activities to the municipality. Also, the legislations cause some restrictions on the amount of e-waste that is allowed to be stored or transported. When this amount is exceeded, the amount of procedures that needs to be executed in order to comply with legislation increases. In that case a guidance form is also needed, reporting to the LMA is required and a permit needs to be requested at the municipalities, all complicating the execution of the daily activities within the chain.

What is the influence of stakeholders on the different supply chain networks?

The stakeholders analysed in chapter 7, have a high influence on the total service on the selected solution. Some network solutions could be completely eliminated, since this was not seen as feasible by a specific stakeholder. The network solutions that require multiple sorting or processing facilities were eliminated, since this was currently not feasible due to the low volumes. Also, repairing products at the sorting facility and direct transportation from the customer to the recycler were eliminated, due to the preferences of the sorting centres and recycling companies.

What is the best supply chain network solution for PostNL and the rest of the network based on the costs and gains?

Based on the cost and benefit analysis a best option is selected. The optimal network is the network using the sheltered workplace as a sorting centre including the following activities: handling and registration, unpacking, internal transportation, storing, sorting and testing of the e-waste. For this network the e-waste is picked up by the sub-contractor driver, who brings it to a depot, from which it is sent to the depot closest to the delivery address. From there it is delivered by another sub-contractor driver to the delivery address. This option exhibits the lowest total cost of the network, after adding the gains, for volumes larger than 5 parcels per week. For volumes larger than 5 parcels per week, the costs of the sheltered workplace are lower than for the comparable options at the fulfilment company.

In this network PostNL functions as a collector of the e-waste. However, this is assuming that the sorting facility in PostNL's network can execute these handlings for a lower cost than the webshops could, when collecting the e-waste. If this is not the case then based on the cost and benefits analysis, PostNL should only be the transporter of e-waste.

What is the optimal supply chain network set up by PostNL in order to return e-waste from the webshops' customer, so webshops comply with the take-back legislation?

The overall optimal solution is the same as the preferred option based on the cost and benefits analysis, which involves the e-waste being taken back by the sub-contractor driver and executing all the activities at the sheltered workplace.

In terms of legislation it is slightly easier to be a collector of e-waste than to be just a transporter. This has to do with the fact that the line between transporter and collector is sometimes a little blurry which results in PostNL beings seen as a collector. When transporting more than 500 kg of unharmful waste an exception position needs to be sought by PostNL to exempt the customer from

filling in the guidance form for the e-waste. Therefore, the network options regarding being a collector are preferred over being solely a transporter in terms of legislation. Moreover, a sheltered workplace is an external party that is already subject to the activity decree, which simplifies reporting to the municipality and therefore this sorting centre is preferred over the fulfilment company in terms of legislation. Also, due to legislation the network structure of a customer bringing their e-waste to a post office when transferring a new product needs to co-exist next to the preferred options.

For most stakeholders the network with the lowest cost is preferred, since they would like to have high volumes. A high volume will most likely be achieved in a collective solution, so most stakeholders prefer PostNL to be a collector. However, a high volume is not preferred by the webshops. Furthermore, PostNL prefers a network using the fulfilment company, since it provides their fulfilment company with extra work.

As stated before, the network options at the sheltered workplace incur a lower cost than comparable options at the fulfilment company with a volume of more than five parcels per week. The lower cost in combination with the preference for an external facility due to legislation makes the sheltered workplace the preferred option over the fulfilment company. The network with the lowest cost could also be the network when PostNL is solely a transporter and this network will then be preferred in terms of cost.

The recommendation to PostNL is that the optimal solution described should be their main option, since it is the best option in terms of cost, legislation and in regards to most stakeholders. Furthermore, in order to fully comply with legislation, the option also offering the possibility to give back the old e-waste at a post office should co-exist next to the preferred option. Another option that could co-exist with the preferred solution is PostNL being a transporter of e-waste when this option is preferred by a webshop. However, when PostNL collects the e-waste from multiple webshops, the volume will be higher as preferred by most stakeholders and the activities become more efficient. Therefore, the option of PostNL being a transporter of e-waste should only be executed when specifically requested by a webshop.

9.2. Limitations

This research is a good start for the unexplored research area in regards to the effect of the WEEE directive on webshops and the subsequent optimal network structure. However, due to its novelty it also has some limitations.

The main limitation is that this research is fully focused on setting up a network that involves the e-waste being given back to a driver or post office, while other options might be possible, if proven to be more effective. Moreover, in the research the e-waste needs to be packed in a box, so it can be transported in PostNL's parcel network. Alternative options, such as transporting the e-waste in a sealed plastic bag, that does not tear or in a foldable box that a sub-contractor driver has in the back of the van, are not explored. Moreover, it might be that the optimal solution to transport the e-waste is not through the existing parcel delivery network, but for example by using another network present at PostNL or even a dedicated network for e-waste. For this research the parcel network of

PostNL, is only researched as a possible take-back network for the e-waste, since this makes the smallest changes to the current operations. Therefore the practical impact is major. However, this limits the academic impact of the network solutions, since it focusses solely on the use of this network. The impacts of the roles, legislation and the stakeholder perspective are more generic and therefore have a larger academic relevance.

Another limitation of the network structure is that it assumes that the e-waste will be processed in the Netherlands but it might be more efficient to be conducted outside the Netherlands.

Moreover, this research involves many analyses of the different concepts, which were needed to come up with an optimal network solution. The limitation of this is that most of these concepts could be a research topic by themselves and therefore only a limited part of these concepts is researched. A limitation to the financial structure is that within the scope of the research only the current option was discussed with some suggestions of structures that could be possible. The option of the municipality or the fund of the NVMP partly funding the take-back network should be explored further.

In regards to legislation no insights are given into how PostNL should deal with the fact that all depots of PostNL might need a permit in order to tranship the e-waste, since this affects a bigger part of the operation than solely the new service. Also, the research does not deal with implementation of this network and the detailed steps that need to be taken to comply with all the different legislations.

A limitation to the stakeholder section is that their points of view could be researched more extensively. For the perspective of the sorting centre and recycler a meeting was held with two parties. Meeting or interviewing more of these stakeholders would make the analysis more reliable. Furthermore, the model only explored the options of sorting centres with which PostNL already has a connection, due to the current low volume.

In case the volume grows majorly more facilities could be needed and decentralisation might be a possible solution for the sorting centre and reprocessing facility. However, due to the current low volume, the options for centralisation are not explored for bigger volumes. The number of facilities and where those should be situated could be calculated with mixed integer linear programming. The uncertainty regarding the volume limits this research.

Regarding the information flows, the research only identified which information flows are needed in the network and it does not elaborate on what systems are used to send the information from one actor to another. It also does not investigate whether the information flows deviate much from the current information flows in place at PostNL and therewith the difficulty of implementing the flows needed for this network.

For the cost analysis a pilot was held with the amount of e-waste available at the sorting facility at that time. This amount was sufficient to get an indication, but not enough to do a proper cost analysis. Therefore, another pilot should be conducted in order to adapt the Excel model when the volumes increase. Therefore, the current model might not be completely accurate for major

increases in the volume. Another limitation is that the output of this pilot is also used to calculate the cost at the fulfilment company. It is not taken into account that the employees at the fulfilment company could have a higher working efficiency than the employees at the sheltered workplace. Finally, parcels could be distributed more often via specific depots instead of the same amount being distributed over all depots. In that case the costs of the internal parcel distribution need to be adapted in the model.

9.3. Future research

As stated in the limitations section, other networks should be researched that could also offer a solution to the take-back legislation. Alternatives to the carton box the customer needs to provide the e-waste with, could also be researched. There might be more effective solutions than the carton box, such as a foldable box.

For the current network, other sorting facilities and reprocessing facilities should also be researched further. Moreover, in the current network it is assumed that the e-waste stays within the Netherlands, but it might be more efficient to reprocess it at a reprocessing facility in Germany or Belgium, which could have an effect on the total network. Also the options of decentralisation could be explored in case there is a major increase in the volume of e-waste. In that case a comparison should be made evaluating the transportation cost compared to facility cost.

All the analyses could be executed in more detail than has been done by the current research, as has been described in the limitations section. Specifically for the financial structure other options could be researched, involving the possible cooperation with the municipalities and getting compensation from NVMP. Also the information flows should be researched more extensively in regards to what information system is used and the difficulty of implementing the proposed information flows.

Finally, the pilot could be performed with more parcels than was done in this research. This pilot could also be run at multiple facilities in order to compare the handling speed and make a better estimation of the costs at different facilities.

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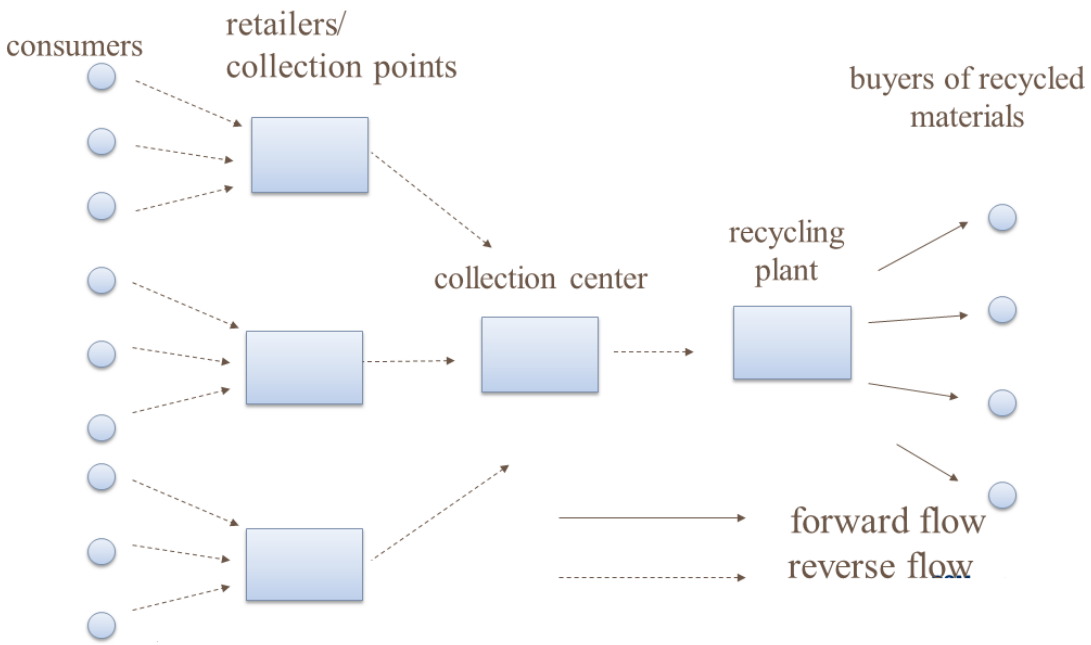
Appendix A

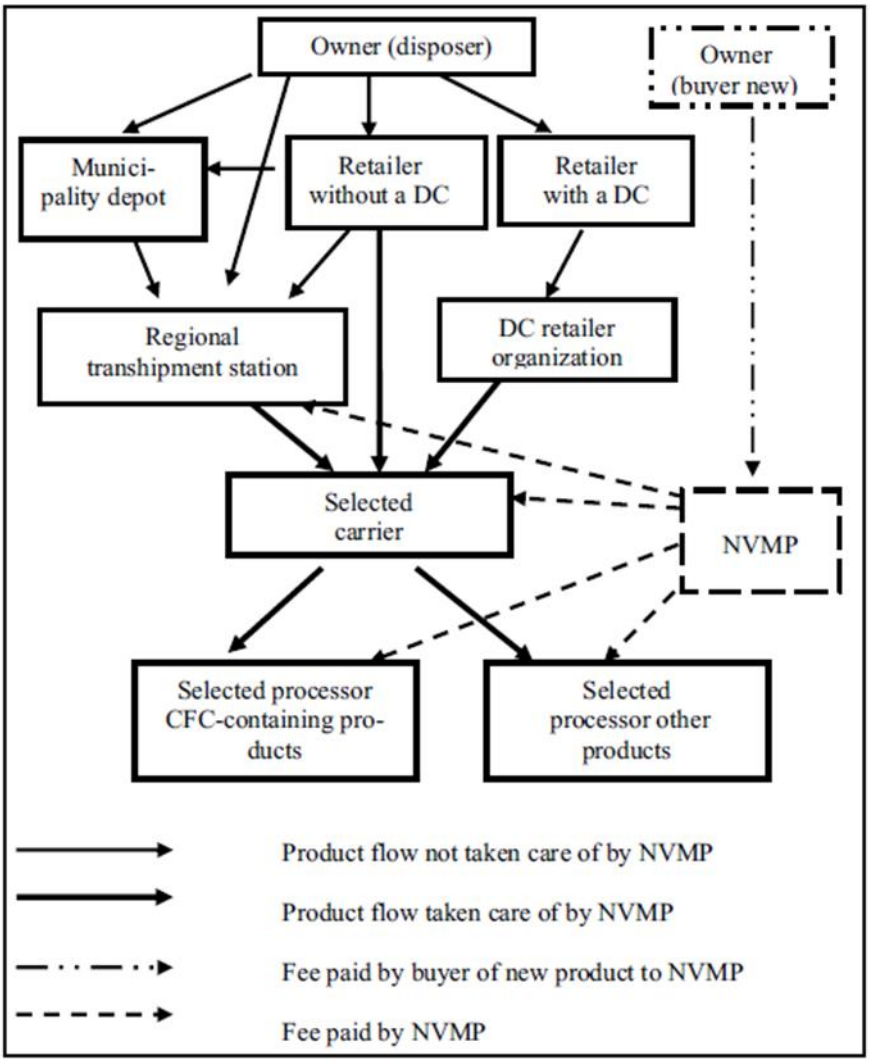
Concepts/factors	Kind of Empirical data	Collection method	Source
Possible roles PostNL	Secondary	Online search engine	NIWO (VIHB registration)
	Primary	Phone conversation	NIWO
Supply chain configuration and management: Supply chain networks	Secondary	Online database	Academic journals
	Primary	Interview/ meetings	PostNL
	Secondary	Company Information	PostNL
Supply chain configuration and management: Financial structure	Primary	Interview/ meetings	PostNL & other RL players
	Secondary	Online database	Academic journals
	Secondary	Online search Engine	Non-academic sources
	Secondary	Internal information	Legislation & stakeholder section
Supply chain configuration and management: Information flows	Secondary	Internal information	Legislation & stakeholder section
	Secondary	Online database	Academic journals
	Primary	Interview/ meetings	PostNL & other RL players
Legislation	Primary	Interview	LMA & Province Noord-Holland
	Secondary	Online search engines	wetten.overheid.nl
	Secondary	Internal information	PostNL
	Secondary	Online database	Academic journals

Concepts/factors	Kind of Empirical data	Collection method	Source
Stakeholders	Secondary	Online database	Academic journals
	Primary	Interview/ meetings	PostNL's Stakeholders
	Secondary	Search engine	Competitors website, market share rankings, thuiswinkel.org
	Secondary	Survey	Intern PostNL
	Secondary	Online search engine	Reports advisory bodies
Performance: costs	Primary	Interview/meetings	Control department PostNL
	Primary	Interview/meetings	Collection centres & recyclers
	Primary	Pilot	Sheltered workplace
Performance: gains	Secondary	Internal information	PostNL
	Primary	Interview/meetings	Sheltered workplace & recyclers

Appendix B



Network in response to take-back legislation slide 34 lecture 3 clcs (Van der Laan, 2013)



End-of-life white goods network structure (de Koster, Flapper, Krikke & Vermeulen, 2005)

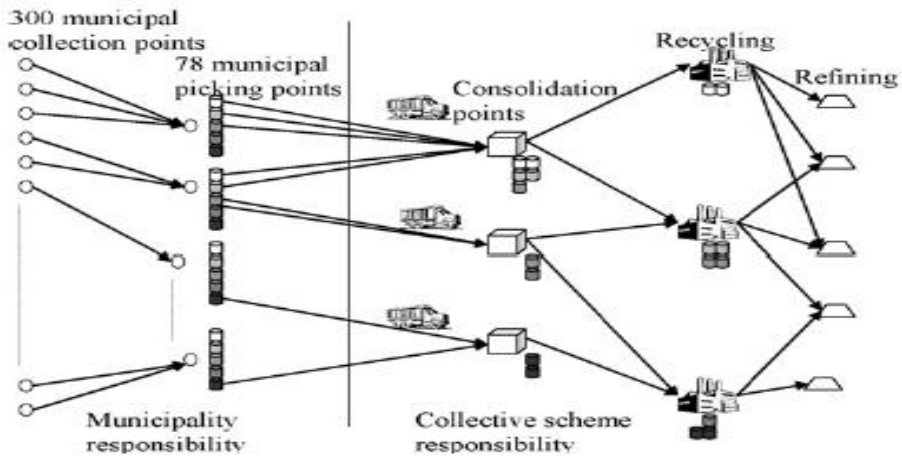


Fig. 1. The configuration of the reverse network.

Reverse network for WEEE in Denmark (Grunow & Gobbi, 2009)

Appendix C

BEGELEIDINGSBRIEF

INTERNE COPIE (D) / EXTRA BEWIJS VAN ONTVANGST (B2) (voor ontdoener)
Verplicht te gebruiken voor transport van afvalstoffen

1
1 ☐ (primaire) ontdoener 2 ☐ ontvanger 3 ☐ handelaar 4 ☐ bemiddelaar
afzender
straat + nr
postc. + woonpl.
VIHB-nummer

2
factuuradres
postbus of straat + nr
postc. + woonpl.

3A
ontdoener
straat + nr
postc. + woonpl.

3B
locatie van herkomst
straat + nr
postc. + woonpl.
datum aanvang transport

4A
uitbesteed vervoerder
straat + nr
postc. + woonpl.
VIHB-nummer

4B
locatie van bestemming
straat + nr
postc. + woonpl.
datum ontvangst transport

5
getransporteerd door: 1 ☐ afzender 2 ☐ ontdoener 3 ☐ ontvanger 4 ☐ inzamelaar 5 ☐ vervoerder 6 ☐ uitbesteed vervoerder (vak 4a)
ontvanger/inzamelaar/vervoerder
straat + nr
postc. + woonpl.
VIHB-nummer
kenteken
route-inzameling ☐ ja ☐ nee
routelijst bijsluiten (zie toelichting)
inzamelaarsregeling ☐ ja ☐ nee
repeterende vrachten ☐ ja ☐ nee
zie toelichting

6

afvalstroomnummer	gebruikelijke benaming van de afvalstoffen	aantal/ verpakking	eural code	verw. meth.	geschatte hoeveelheid (kg)	

Het vervoer geschiedt op de door sVa / Stichting Vervoeradres ter griffie van de arr.rechtbank te Amsterdam en Rotterdam gedeponeerde algemene voorwaarden voor het afvalstoffenvervoer over de weg, laatste versie.
Voor aansprakelijkheid vervoerder z.o.z. In de vracht is verzekering niet begrepen

handtekening afzender	handtekening ontdoener	handtekening transporteur voor ontvangst der zending met gelijkgenummerde vrachtbrief	handtekening ontvanger (geadresseerde) voor goede ontvangst der zending met gelijk-genummerde vrachtbrief

De begeleidingsbrief dient naar waarheid ingevuld te worden en is alleen geldig als de verplichte (donkere) velden zijn ingevuld en de handtekeningen zijn geplaatst door daartoe bevoegde personen. De donker gearceerde velden zijn soms, afhankelijk van de omstandigheden, verplicht (zie toelichting op de achterzijde van dit formulier)

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