Cost Calculating Model for Electronic Waste Management

An Interactive Qualifying Project submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

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May 6, 2012

Abstract

Danish legislation aims to hold producers of waste from electrical and electronic equipment (WEEE) financially responsible for the disposal of their products, but there is no method to accurately calculate their WEEE collection cost at municipal container stations. We developed a fair and simple model, consisting of a spreadsheet that totals all the WEEE costs, and estimated the annual cost for collecting WEEE in Denmark as 68,200,000 DKK.

Acknowledgments

The authors wish to thank everyone who generously contributed their time and efforts through the completion of this project. We would like to thank our sponsor, RenoSam, our liaison Niels Remtoft, and organization Director Jacob Hartvig Simonsen for hosting this project. We would like to thank Professor Lorraine Higgins for her guidance throughout this project and for her mentoring during our stay in Copenhagen. We would like to thank the intermunicipal companies that generously helped provide feedback on our project. We would like to thank Professor Scott Jiusto for his instruction and assistance during the preparation phase of this project. We would like to thank Professors Peder Pedersen and Tom Thomsen for their outstanding efforts in maintaining the Copenhagen project center, for establishing our project, and providing us with background information on Danish culture and history. Finally, we would like to thank Mogens Larsen for introducing us to Copenhagen and the Danish language.

Authorship

This project was completed by the efforts of Alexandra Clemente, Ben Franzluebbers, and Bryan LaRochelle. Each person has contributed equally in writing and editing. Preliminary research was divided based upon subject matter. Alexandra examined cost models in general, Ben examined WEEE and the processing of it, and Bryan examined the waste management structure and legislation in Denmark. The initial drafting of these sections were concluded by their respective researchers. Editing was shared by all, as each section underwent numerous revisions. While on site, the work load was shared in a similar manner. During interviews, Alexandra and Bryan focused on questioning while Ben focused on note taking. In developing the Excel spreadsheet, Bryan worked on the initial outline, Alexandra worked on the formatting of it, and Ben worked on the final cost estimations of the surveyed companies.

As a group, we all have learned more about research and writing, organization, and of course WEEE and waste management in Denmark. Being able to write about research that we've concluded and support our claims with relevant facts was a major portion of this report. We've each learned more about this process and how to accept constructive criticism on our writing. A major challenge in writing about this project was the organization of its writing. Developing this model was an ongoing process, so fitting the writing into the typical IQP form was difficult. Our final paper reflects more of a storyline approach in which we discuss our initial efforts and how we refined it. Obviously, we've learned much about WEEE and waste management in Denmark. From our site visits, we've seen firsthand the collection of WEEE and other waste streams. We've also gained in depth knowledge on extended producer responsibility and its adaptation in Denmark from interviews with major stakeholders. Once again, all work was shared equally by the authors, and through this process, we've gained much insight on WEEE collection in Denmark.

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Executive Summary

With the ever increasing efforts to produce more and better technology, electronic products are often discarded for the new, best thing. Waste from electrical and electronic equipment (WEEE) makes up a significant portion of the waste generated. To combat this growing waste, keep with the trend of "going green", and promote reuse of our world's precious resources, efficient waste management strategies for WEEE are being developed and fine-tuned in Europe. Denmark is a leader in clean energy and advanced recycling, and like other countries in the European Union (EU), has enacted laws on extended producer responsibility (EPR). EPR holds producers financially accountable for their products at the end of their use cycle, and it is aimed to promote ecologically-friendly engineering and design. In Denmark, producers are required to cover the finances for their end of use products at stages beyond the collection such as transportation, treatment, and remanufacturing. Producers are not required to pay for the collection, and as a result municipalities are absorbing the cost to collect WEEE. Currently in Denmark, new WEEE legislation is being drafted to hold producers fully responsible, including the collection process. In order to enforce any sort of new legislation regarding the collection of WEEE, a method to calculate the cost of collecting WEEE is required.

WEEE makes up a significant portion of the waste generated and collected. In Denmark, waste is collected at local container stations run by intermunicipal waste management companies. Sponsoring this project is RenoSam, who is an association that encourages cooperation between waste management facilities and companies and advocate for its member organizations' interests. The results of this project will aid RenoSam in lobbying for full producer cost financial accountability.

The focus of this project was to create a cost calculating model for the collection of WEEE at municipal container stations. This model needed to be transparent, simple, and accurate. Our intent was to create an Excel spreadsheet that could be used to easily collect relevant WEEE costs from municipal companies. We developed and tested our model by using it to calculate an estimate for the total cost of collecting WEEE in Denmark.

To achieve our objective, we researched the Danish waste management system, its legislation on WEEE, and cost models from other countries. From this we created a preliminary

list of cost items that we would turn into a spreadsheet for collecting data and calculating costs. This spreadsheet underwent several revisions as we got feedback from three municipal waste companies whom we visited in person. An improved spreadsheet was then sent to seven additional municipal companies. We entered the data we obtained from this survey and calculated an estimate for collecting WEEE in all of Denmark.

A major obstacle to developing this model was maintaining its simplicity while still being transparent. We discovered that we had to simplify our line items into total costs for staffing, real estate, maintenance of the facilities, equipment, utilities, bulky waste collection, and WEEE specific costs instead of asking for detailed values. Another revision involved our method of allocating the costs of waste management pertaining to only WEEE. Originally, we planned to find the percentage of total costs that were specifically for WEEE based on weight but then realized from on-site discussions that weight alone is not accurate enough. Allocation based on volume or time can yield very different ratios. We settled on an allocation method that accounts for three factors: weight, volume, and time.

The finalized model was used to determine collection costs from intermunicipal companies. We sent the Excel sheet electronically to intermunicipal companies. After they filled in the information we calculated an estimate for the total WEEE collection cost in Denmark. We found that the total cost to collect WEEE in Denmark is approximately 68.2 million Danish Kroner. This number is close to the previous rough estimate that RenoSam made.

In order to gain a holistic understanding of extended producer responsibility, WEEE, and how our model might be used, we interviewed major stakeholders: representatives from a producer organization and the Danish Ministry on the Environment. After sharing our model and soliciting feedback, we formulated concise recommendations for the use of this model in the future and its implementation in Denmark. Most notably, we found that use of the model needs to refrain from putting any additional administrative burdens on those responsible for filling out the spreadsheets. The calculated cost and the associated fee billed to the producer should also evolve into a standard figure that each producer has to pay, instead of a yearly calculated value. We end this report with recommendations such as these for use of our model.

Chapter 1: Introduction

Developments in technology and the mass production of goods in the world today have increased the amount of waste generated. The electronics produced every day need a final resting place. Some of these products are not only toxic, but they are depleting the world's natural resources -- the metals and other natural substances used to produce these goods. Authorities are beginning to combat this problem by recycling and remanufacturing electronic waste. The companies who manage waste from electrical and electronic equipment (WEEE) are forerunners in this field of reverse manufacturing. Denmark, with more than 80,000 tons of WEEE collected in 2010 (DPA System, 2011b), has made it a priority to address this problem. Denmark's reputation of environmental stewardship has served as a paradigm of exemplary waste management.

A strategy to counter this depletion of finite resources is for producers to create electronics that are more environmentally friendly. The way WEEE management authorities have decided to accomplish this is by holding producers financially responsible for the waste generated by their products. Extended Producer Responsibility (EPR) means having the producer pay costs associated with any recovery or disposal cycles at the end of life of any merchandise they place on the market. It is in a producer's best interest to reuse or recycle what they create. This will deter producers from manufacturing harmful and environmentally destructive products. For this purpose, the European Union (EU) put out a Directive in 2002 recommending that producers be held financially responsible for the end of their electronics' life cycle. This includes all transportation, collection, sorting, shredding, and dismantling costs. Currently producers pay for the transportation and treatment of waste, but Danish municipalities still pay for the cost of handling WEEE at collection stations. Handling costs include separating wastes in different containers, with one being specifically for electronic waste, and storing it until producer schemes transport it to further processing. Municipalities feel that producers should cover these costs as a result of Extended Producer Responsibility. The producers, however, feel that this would be unfair, since municipalities have no reason to minimize their WEEE handling costs if they are not responsible for its payment. This dilemma has provoked new efforts to estimate the costs of WEEE management. In Denmark, an accurate

and fair model for the collection and handling of WEEE is necessary so that producers can be held responsible for the full cost of recovery.

Research has been conducted on enacting producer responsibility for WEEE disposal. An analysis by Bohr (2007) looked at the overall economics of WEEE recycling from the stages of collection to final treatment. Bohr created a model that predicts the cost of handling WEEE at each stage of the process, including collection. Some EU member states have developed their own cost models to hold producers responsible for the collection of WEEE. In Holland and Belgium comprehensive models have been made to gather pertinent cost information from individual collection stations. There have also been some attempts to calculate the cost of WEEE collection specifically in Denmark. RenoSam, an organization of 42 intermunicipal waste management companies from across Denmark and the Faeroe Islands, made a rough estimate of the total cost of handling WEEE at container stations in 2011. This estimate found that the total cost was up to 80 million DKK (approximately 14 million USD) per year. This rough estimate was based on a selective few container stations and the number of visitors per year, and that average was taken and extrapolated for the entirety of Denmark. This is not to the degree of accuracy needed for a strong lobbying case. This estimate drew from rough data provided by the individual municipalities without any criteria. A transparent model that details systematically which costs are required to construct and operate a waste collection station will provide for a much harder argument in favor of holding producers fully responsible.

Despite the fact that there have been more accurate, systematic, and comprehensive cost estimations of WEEE collection done in other countries, there has yet to be one developed in Denmark; likely due to the difficulty in accounting for the variations between the different municipal container stations. These variations include the size of the station, the number of employees, hours of operation, and manner of operation as well. In order to develop a successful and accurate model which encompasses all 392 of the container stations, the spreadsheet must be able to account for these variations. In this project, we developed a simple and effective cost estimation model based on work concluded by Philip Bohr and models from Holland and Belgium. This model includes a combination of line-item analysis from representative sample container stations which factor in variations on the size and density of

collection stations. By using and testing this model, we are able to estimate a yearly cost per ton for collecting WEEE at municipal container stations.

The ultimate goal of this project is to work with RenoSam to create a simple and transparent cost calculating model for handling WEEE at Danish municipal container stations. This model will be used to lobby for full cost recovery legislation as stipulated in the European Union Directive. The hope is that expanding the financial responsibility to the producer lead to more ecologically aware product engineering. This project will rely on a study of similar cost estimation models, an intricate understanding of the current Danish WEEE management system, and actual data gathered from sample Danish container stations in order to create an effective final deliverable.

Chapter 2: Background

In this chapter we will examine the main thematic components to our project. While our study and cost estimation model will be specific to Denmark, it is important to first understand more about WEEE, waste management, and cost estimation models. We will also look at the legislative forces inspiring our project. We will study other countries' interpretations of the European Union legislation regarding this matter and the way they handle WEEE and producer responsibility. Through these studies, together with a thorough understanding of the Danish philosophy towards WEEE, we aimed to successfully prototype, test, refine, and finally present to RenoSam a model which will be used to lobby for full cost recovery in connection with producer responsibility.

2.1 What is WEEE?

WEEE stands for Waste from Electrical and Electronic Equipment. This section will look at potential dangers of WEEE and legislation pertaining to this topic. The European Union's Directive on WEEE outlines what characteristics cause waste to be considered WEEE. There are ten categories of electrical and electronic equipment of WEEE, including:

1. Large household appliances
2. Small household appliances
3. IT and telecommunications equipment
4. Consumer equipment
5. Lighting equipment
6. Electrical and electronic tools (with the exception of large scale stationary industrial tools)
7. Toys, leisure, and sports equipment
8. Medical devices (with the exception of all implanted and infected products)
9. Monitoring and control instruments
10. Automatic dispensers

(The European Parliament and the Council of the European Union, 2003).

Equipment that does not use electricity or uses electricity for only secondary functions, large industrial tools, and equipment used for military purposes, such as weaponry, are not considered WEEE under the EU directive (Day, 2005).

2.1.1 Problems with WEEE

The reason there are laws regulating the disposal of WEEE is because WEEE can be harmful to the environment. Certain types of WEEE can be especially hazardous. He et al. (2006) note that items such as thermostats, sensors, medical equipment, cell phones, and gas discharge lamps contain significant amounts of mercury. The cathode ray tubes used in televisions and computer monitors contain lead and printed circuit boards contain hazardous amounts of cadmium (He et al., 2006). All of these materials are very toxic and can cause serious ailments if ingested (or inhaled in the case of lead and cadmium) in large quantities (Hutton, 1987). There are differences between various categories of WEEE, and different treatments are required to safely dispose of the dangerous materials each type contains.

There are also safety and social issues involved when WEEE is exported and dealt with elsewhere. If waste is sent to a country with low health and safety standards, then the WEEE can be disposed of in a cheaper but unsafe manner. This coincides with the dire necessity for new and advanced technologies in these developing countries to be able to compete and communicate with the modernized world. This issue has been addressed by international law in the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and their Disposal (Puckett, Westervelt, Gutierrez and Takamiya, 2005). The Basel Convention looks to protect the interests of the developing nations while making sure the waste, including WEEE, is disposed of accordingly. Puckett, Westervelt, Gutierrez and Takamiya (2005) report that developed countries were sending computers to Nigeria to be reused, but since these computers were not tested beforehand many of them were actually useless waste that would build up in their landfills. In many instances, such as this, WEEE is exported to countries that lack serious disposal regulations. The waste is further sent to landfills without receiving treatment to safely remove toxic materials. While some of these infractions are penalized, many of these go unnoticed. There is currently no system in place to account for these illegally transported electronics. GPS tagging each piece of WEEE individually is far too expensive to

conceive. Also most customs and border patrol offices around the world are using most of their resources on other illegal exports like drugs and weapons.

Another problem with poor WEEE disposal is the waste of resources it presents. Many of the components from electronics come from finite resources and could be recycled through proper treatment. As these finite resources deplete, the cost of obtaining them increases. As the materials in WEEE increase in their monetary value, so does the competition to obtain them. This surge in urban mining turn leads to illegal streams of WEEE disposal. In further sections we shall analyze the WEEE Waste management process in Denmark and elsewhere and what measures are in place to ensure this is done as safely and effectively as possible.

2.2 Legislation on WEEE

To prevent improper waste management, countries enact laws which prohibit unnecessary landfilling and promote recycling. This section will begin to look at some of the legalities involved in WEEE management.

A major objective of the laws on waste management is to prevent further depletion of natural resources by reusing, recycling, and remanufacturing the products that have already been created. The metals found in electronics can include precious metals such as gold, platinum, and silver or other metals such as copper, tin, aluminum, and iron. These elements are finite. It is preferable to reverse manufacture electronics than to completely dispose of it at the end of an electronic product's life. Reverse manufacturing creates a new product from used components rather than new raw materials. The ultimate depletion of some of the world's precious resources can be prevented by prudently reusing natural resources. In order to successfully complete our project it is important to address aspects of WEEE management touched upon in the EU directive and Danish legislation. For the scope of our project, these aspects don't include the toxicity of materials or the Restrictions on Hazardous Substances (RoHS), which are outlined in a different directive by the European Union.

2.2.1 European Union Legislation

One of the most important driving forces in this project is the legislation set in place by the European Union regarding who is responsible for covering the cost of WEEE recycling. The EU is an international organization that is made up of 27 European countries and its aim is to

govern common economic, social, and safety issues. This organization was created in 1993 and has since passed directives to address currency, citizenship rights, unified foreign policies, and environmental stewardship (Encyclopædia Britannica, 2012). The EU often serves as a great source of unanimity between most of Europe, although member countries may disagree on some of their policies. Every country is not required to join, but a large majority of countries do and follow its directives and suggestions. Denmark has been a member of the EU since 1973 and has followed many of the organization's directives and principles.

In 2002, the European Union drafted a directive that addresses the issue of producer responsibility on waste from electrical and electronic equipment (WEEE). It requests that EU Member States enact rules on the waste management of electronic waste. This includes WEEE collection, treatment, and recovery, all of which producers and importers are held responsible for (The European Parliament and the Council of the European Union, 2003). Therefore, a process needs to be in place for electrical and electronic equipment (EEE) to be collected. This may include collection (drop-off) centers or pick-up services. A method for recycling parts from old equipment also needs to be developed. Finally, a recovery process for the products to be reintroduced to the manufacturers is necessary. As Denmark is a member country of the EU, the Danish Ministry of Environment was tasked to adapt this directive for the Danish system.

This EU Policy outlines what is known as Extended Producer Responsibility (EPR). EPR is defined as "an environmental protection strategy to reach an environmental objective of a decreased total environmental impact from product, particularly the take-back, recycling and final disposal of the product" (Bohr, 2007). This not only makes the producers materially and financially responsible for the waste they product, but it also forces them to emphasize research and development focused on the creation of greener technology. EPR is a concept we will be revisiting in different sections of this study.

This project touches upon what obligations the individual consumer has. The EU Directive states that responsibility is also partially placed upon the consumer. Most of the electronic market is to private buyers, and as an incentive, the EU states users should be allowed to return their WEEE free of charge. This means that consumers need to be educated about these wastes and how they can help manage them. It is the producer's responsibility to

provide information about the materials and components used within their products so proper care can be given at an electronic product's end of life.

The EU Directive on WEEE largely aims to place more responsibility on the producer. It states that a producer is any person who manufactures and sells electrical and electronic equipment, resells equipment under his own brand, or imports or exports electrical and electronic equipment (The European Parliament and the Council of the European Union, 2003). The idea behind accountability for all EEE producers is that the creator or whoever introduces a product to the domestic market is held financially responsible for any sort of wastes or byproducts they produce. This will hopefully deter them from creating harmful and environmentally destructive products. If it costs the producer more money to pay for the recycling and recovery of their wastes they may try to avoid these costs by being more environmentally and ecologically friendly from the start.

2.2.2 Denmark Legislation

Denmark has enacted a law on WEEE in response to the EU Directive. The most recent order entered into force in Denmark on 15 April 2010, which repealed a previous order from 27 June 2005 on the same issue. The Ministry of the Environment is the Danish governmental agency that protects the environment. It is Denmark's Environmental Protection Agency, and it advises the government on environmental programs, develops and proposes rules and measures, acts as an advocate to the public and industry, and organizes data about the environment (Danish Ministry of the Environment). The Ministry has been around since the 1970s and it addresses many pertinent topics, including electronic waste.

The Ministry of the Environment appointed the Dansk Producentansvarssystem (DPA-System), a non-profit organization to keep record of all the electronic producers and importers on the market (Danish Ministry of the Environment, 2006). Since Denmark is a small country which imports most its goods, there are more importers than producers in this system. We will use the term producer and importer interchangeably throughout our project as both have the same obligations under Danish law. It is up to DPA-System to decide whether the electrical and electronic equipment that the producers register is covered by the rules of producer

responsibility or not. Annually collecting data from the producers and reporting it to the Danish Ministry on the Environment is also DPA-System's responsibility.

DPA-System is at the center of a web of individual waste management entities. The DPA-System's website describes this system as shown in Figure 1 below:

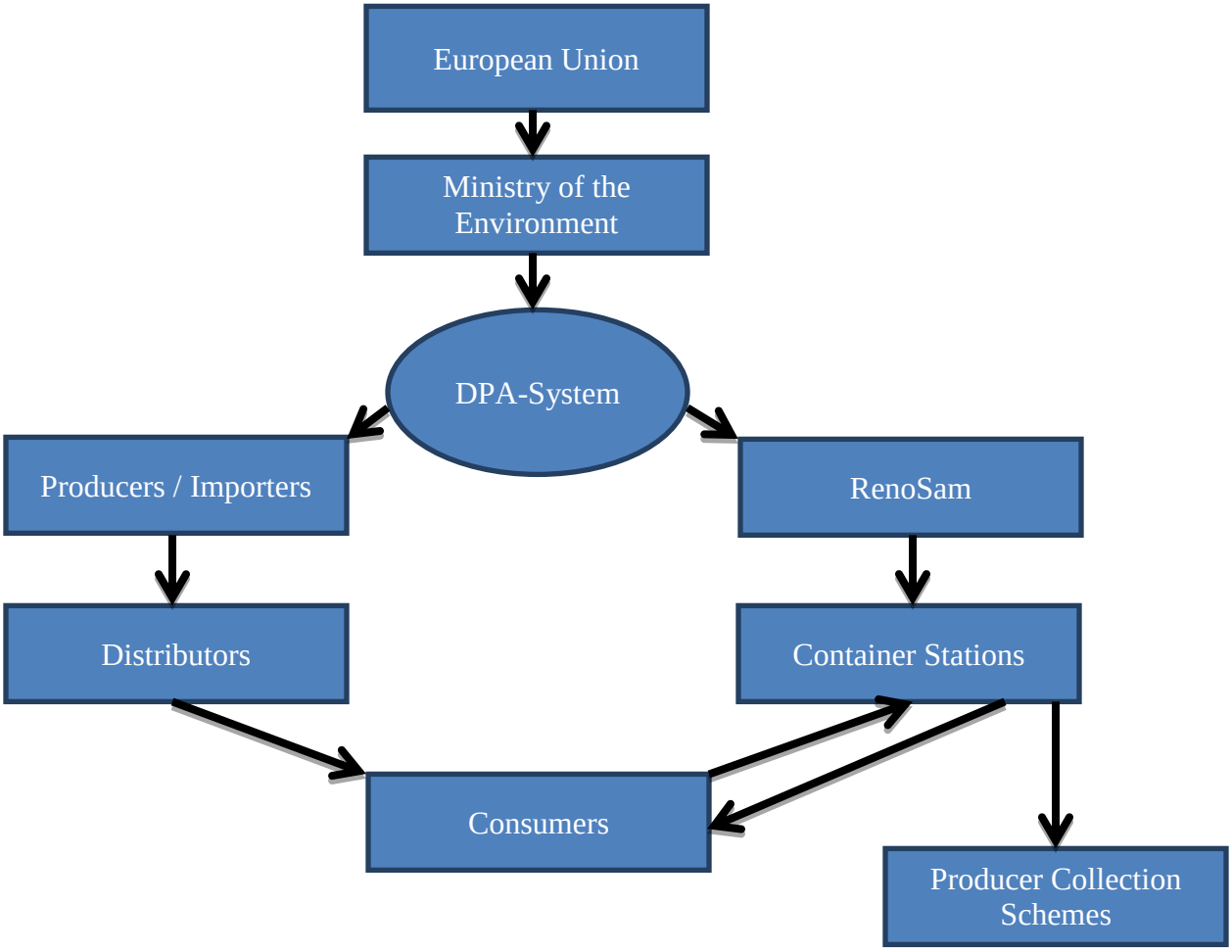

Figure 1 WEEE Management System in Denmark

As Figure 1 shows, the system revolves around DPA-System. Since DPA-System collects all the data regarding the wastes, they act as a central hub for the whole waste management organization. The top of the figure shows how the Ministry of Environment (EPA) oversees the rest of the scheme. Producers and importers report to DPA-System as well as follow the regulations set out by the EPA. DPA-System keeps record of what the collection stations receive and associate fees with their quantity of waste. It is also important to note that while the EPA is a politically active entity within the Danish Government, the DPA-System isn't. The DPA-System

can serve as a commentator on bills regarding EPR and WEEE matters but cannot directly advertise or campaign for them in Parliament.

According to the DPA-System's website, there is a onetime fee of DKK 1,000 per producer or importer when registering with DPA-System. There is also an annual fee calculated in relation to the quantity of waste they produce, as reported in their annual report. This fee, set by the Ministry of the Environment, covers administrative tasks and special services that DPA-System and the Ministry provide and maintain.

DPA-System says that "registration is statutory for electrical and electronic equipment covered by the producer responsibility scope" (DPA System). Producers must register with the DPA-System before they can market their goods in Denmark. According to the Danish Statutory Order on WEEE (2006), when registering with the DPA, the producer agrees to provide a financial guarantee for its products on top of the annual fees to the DPA-System. This guarantees that the producers will cover post-use costs. These costs include the transportation, sorting, and secondary treatment of WEEE once it is collected at municipal container stations by producer collection schemes, which will be described in more detail later in this chapter. This guarantee does not currently include the actual costs associated with collection and the container station. Our project is to address this gap in the system and the expansion of EPR. The magnitude of this guarantee is to be decided by DPA-System and is based on the quantities of waste and the known or expected cost of managing the waste (Danish Ministry of the Environment, 2006). As mentioned, producers and importers must keep detailed records on the amount they sell, and they are required to annually report to DPA-System those figures.

When a producer/importer is registered in Denmark, they can decide to join a collective scheme or form an individual scheme. Collective schemes are groups of producers that have decided to come together to fulfill their responsibilities as set forth by the DPA-System, including registration, waste and data recollection, waste treatment, and a financial guarantee for all these activities. Producers can also decide not to take part in these collective schemes, in which case they must still fulfill all these responsibilities but have additional requirements because of the smaller volume of waste they handle. Once DPA-System has all the numbers of products sold collected from all the schemes, the take-back system for the

following year is established. The take-back system is established differently for all 5 categories of commercial WEEE collected in Denmark. Because of the "extensive task in terms of administration, logistics and communication" that creation of these take-back systems represents, the DPA-System "recommends producers and importers selling products destined for private use to join a collective scheme" (DPA System). Two of the largest schemes are Elretur and ERP. Both have been in existence for the longest and represent many major importers such as Sony and HP.

The municipalities have been in charge collecting WEEE since the early 1990s. Local councils establish WEEE collection systems that allow consumers to dispose of their waste. These systems are proportional in size to the population and area they serve. The inhabitants of that municipality have to pay an annual collection fee and are required to get rid of their waste using the services their municipality has to offer. Many of these services are controlled by a centralized intermunicipal company, operated by the local authorities of one or more municipality. In Figure 2, the relationship between the container stations, municipalities and interemunicipal waste companies is explained schematically. While the municipalities create their own rules and regulations, they must all fall inside the boundaries of the legislation on WEEE established by the Parliament.

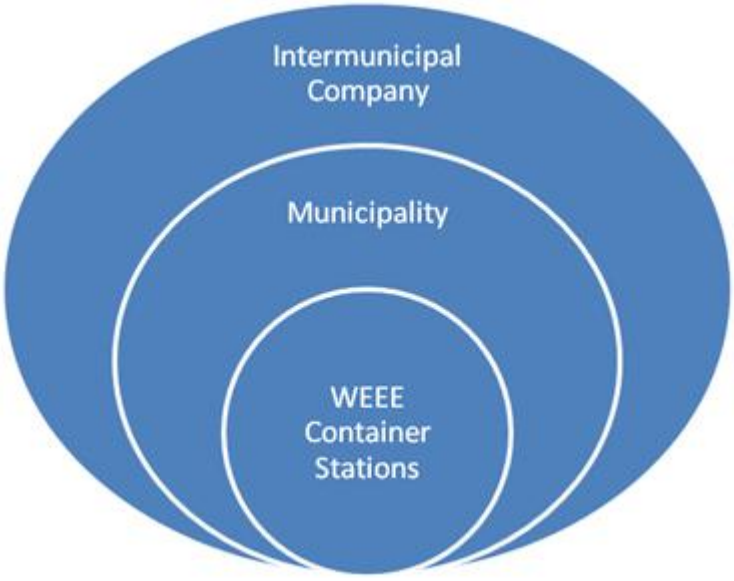

Figure 2. Relationship of WEEE collection entities in Denmark

The legislation on the disposal of WEEE varies greatly depending on the origin of the waste. Private WEEE is usually treated differently than commercially created WEEE. This is because of the differences in mass and volume between them, usually commercial producers create much more WEEE than the private consumer. If the end user of a product is a commercial or industrial entity or the end user has a large quantity of WEEE, then the waste must be delivered to the producer or a collection point established by the municipality. In our study, we only examined the private consumers' wastes and smaller quantities as the commercial drop off at collection points is not financed by the municipalities. For this project, DPA-System was a good source for data pertaining to quantities of wastes.

2.3 RenoSam

The 392 collection centers and container stations in Denmark are often run by local municipalities. There may be more than one container station in each municipality depending on its population and area. Throughout Denmark there are 98 municipalities, and it is important that they are as equally represented as the producers are. Most municipalities have united under umbrella organizations focused on lobbying and protecting their interests. RenoSam is one such organization that we will be working with on this project.

RenoSam, the sponsor for this project, is a consulting and advocacy group in Denmark. RenoSam describes themselves as a collection of 42 intermunicipal waste management companies from across Denmark and the Faeroe Islands. These companies may represent local authorities, companies, or transfer stations. RenoSam's ultimate goal is to protect its members' interests. They deal specifically with improving the processes of recycling, incinerating, and the disposal of waste and hazardous waste (RenoSam). A list of these member organizations and their respective municipalities can be found in Appendix B.

Antonellis et al. (2011) describe RenoSam's role as trying to "affect the national regulations and to influence and recommend to Danish politicians the best practices in the waste management area". RenoSam advocates for its members and lobbies for Danish legislation to promote high environmental standards. They work closely with the Danish EPA to enforce rules and statutes. They also hire consultants and research institutions to help make

new policies governing waste management and to provide information on operational and systematic problems.

RenoSam is organized into Topic Groups and Working Groups. Topic groups are run by a chairperson chosen by the group of directors. This group coordinates the different areas of work. Most of the work in RenoSam is completed by the Working Groups with the assistance of staff from associated member companies. The Topic Groups are divided into recycling, hazardous waste, incineration, landfill, planning and collection, management and competence development, and internal management. Within all these groups, Working Groups have been developed to address the daily issues and projects (RenoSam).

2.4 WEEE Management

To understand what specifically happens at the collection stations, we must first examine the whole waste management process for WEEE. There are several different ways to deal with WEEE. The main methods include reusing, recycling, incineration, and disposing in a landfill. Reuse is when the product is repaired to work as it was originally intended. Recycling waste recovers certain desirable materials, with the rest being disposed of. Burning waste to produce energy is called incineration. WEEE that is either recycled or incinerated for energy is considered to be recovered by Denmark (DPA System, 2011b).

2.4.1 Processes Involved in Handling and Treatment of WEEE

One of the possible ways to dispose of WEEE is to recycle it and take out valuable raw materials. Sims Metal Management Limited (Sims Metal Management Limited, 2012) describes one example of how WEEE is processed. Workers sort through the materials to make sure that certain items, such as batteries, are taken out. The materials are then sent to a machine that crushes everything down to fewer than 100 mm so that the materials are easier to process. Next, the materials are put into a shaking hopper which agitates the materials so that pieces are more evenly spread out along a conveyor belt. The materials move into a machine that removes dust and again reduces the size of individual pieces (Sims Metal Management Limited, 2012).

Next, the stream of materials moves on to the sorting phase. This step sometimes involves hand sorting of materials. Magnets are used to separate ferrous materials, mainly iron

and steel, from the rest of the stream (Sims Metal Management Limited, 2012). The ferrous materials are stored and eventually sold, typically to be used in iron smelters (Bohr, 2007). The rest of the stream is subjected rapidly alternating magnetic fields to separate the remaining metals from the mostly nonmetallic materials (Sims Metal Management Limited, 2012). From there the metals are stored, sold, and eventually reach copper, aluminum, zinc, and lead smelters (Bohr, 2007). Water separation or sensor technology is used to separate the useful printed circuit boards (PCBs) and copper wire from the plastics, with the PCBs and copper being stored and eventually sold (Sims Metal Management Limited, 2012).

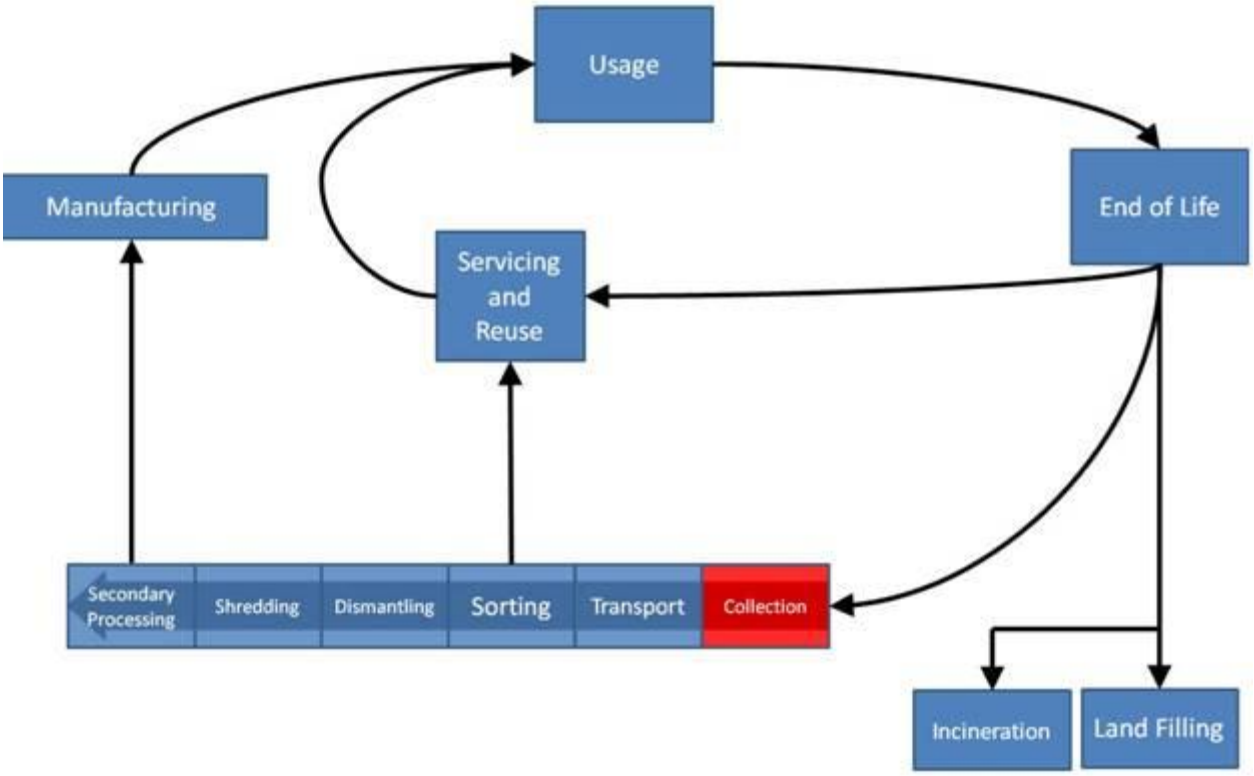

Figure 3. EEE Life Cycle based on Bohr (2007) and He et al. (2006)

While our project is focused on studying the collection stage, highlighted in red above (Figure 3), it is important to gain a full understanding of the whole life cycle of EEE. By understanding the overall process, we are able to put our work and the possible cost the producers would have to pay into perspective. The following sections highlight the specifics of

each of these activities. We focus mainly on the collection as it relates directly to our project. We also give a brief explanation on how the steps are currently done in Denmark and if either the municipality or the producers are currently paying for it.

2.4.1.1 Collection

Collection is defined as the transportation and storage processes that take place prior to the in-depth sorting and processing of the WEEE. There are different types of collection schemes used in Danish municipalities. For the specific case of Denmark, a schematic of the collection process can be seen in Figure 4. This is the process that takes place in most of the municipalities. There might be local variations depending on availability of space, resources, and municipality-specific legislation.

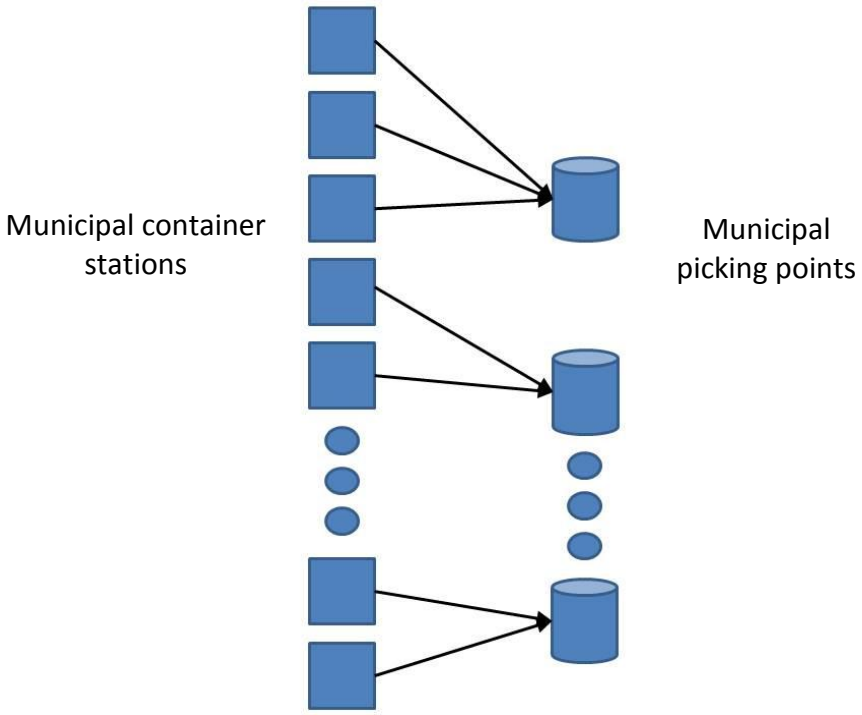

Figure 4. Collection of WEEE in Denmark. Adapted from Grunow and Gobbi (2009)

Figure 4 shows the portions of the process that fall under the financial responsibility of the municipality. The municipal container stations are defined as the stations where the citizens drop off their WEEE. The municipal collection points are the places where the producer schemes collect the WEEE. Since we are not looking at what happens once the producers pick

up the waste we will only be studying the collection that takes place through the municipal container stations, represented on the left of Figure 4.

2.4.1.2 Transport

WEEE is transported at several points during its treatment. As Figure 5 shows, after WEEE is collected at the municipal container stations in Denmark, it is typically sent to municipal picking points, where it is sorted. Then it is transported from the municipal picking points by the producer schemes to WEEE consolidation points, where the waste from multiple sites is combined and eventually sent to the treatment facility to be recycled (Grunow & Gobbi, 2009). In this figure, the blue section represents the stages that fall under the financial responsibility of the municipalities and the orange sections are those that are paid for by the producers through the fees set by the DPA-System and physically taken care of by the producer collection schemes. The WEEE also is transported from sorting to dismantling and shredding, from shredding to other processing, and sometimes from secondary processing to further refining. These stages currently fall under the producers' financial responsibility. WEEE is typically transported in trucks carrying containers of various sizes (Bohr, 2007). As a result, distances travelled and container sizes are some of the main variables that affect WEEE transportation.

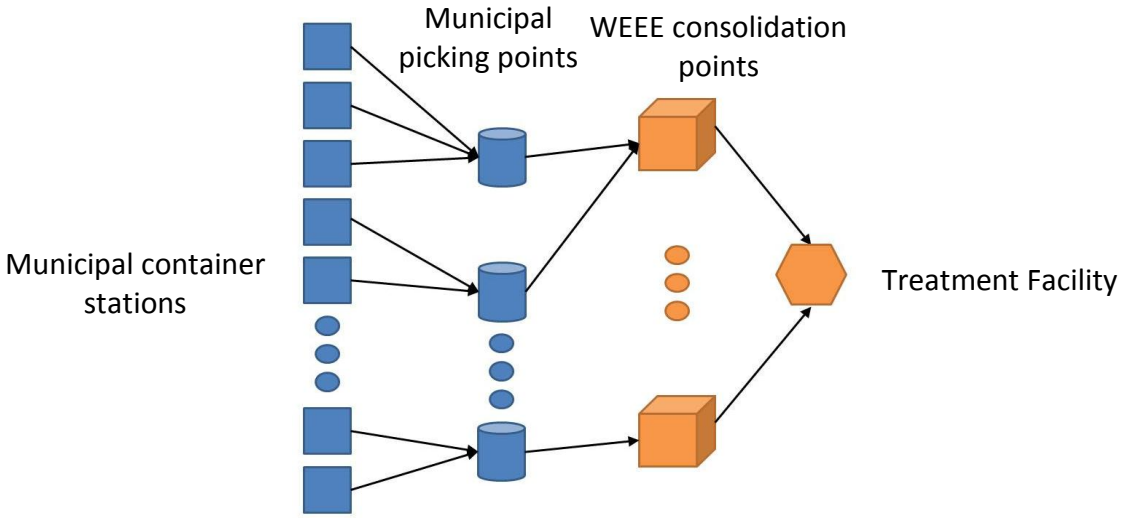

Figure 5. Collection and Transportation of WEEE. Adapted from Grunow and Gobbi (2009)

2.4.1.3 Sorting

Sorting happens at several different points within the waste management process. A preliminary sorting step happens as the electronics first make it to the collection center. The waste is assessed for its usability. If it can be reused or resold it gets put aside and often considerable revenue can be made. WEEE that has no potential for resale is sorted into different recovery streams based on their material composition. Some electronics have more precious metals, so they are sorted and then processed differently. It is also during this stage that data is collected about what is being recovered (Bohr, 2007). In Denmark, there is an initial sorting in the collection points, where WEEE can be separated into different containers depending on its classification. The main sorting is done by private contractors within the producer schemes.

2.4.1.4 Dismantling

Only about half of collected WEEE is dismantled; the rest goes straight to shredding and separation. Hazardous components and polluted wastes, valuable components, or unwanted parts are often dismantled. Hazardous substances such as mercury, lead, and flame retardants are frequently found in electronics and must be safely removed. According to Bohr (2007), most dismantling operations are manual processes because semi-automated processes have proven to be challenging for designers. This results in higher labors costs and slower processing as humans are required to disassemble equipment by hand. Robotic dismantling has proven to be difficult because of the necessary degree of screening for valuable or unwanted hazardous components that is required for this process. Obviously, more time is spent on finding valuable components because they provide income, but there are also economic disincentives for a lack of depollution. Depollution removes materials and components that contain restricted or hazardous substances. There can be fines and fees for not completely removing hazardous substances as defined by the Restrictions on Hazardous Substances (RoHS) laws in a given area. In Denmark, dismantling is usually done by a contractor outside of the municipality, sometimes specialized in handling RoHS. These companies can then transport the remaining scraps to separate companies for the following processing steps or do those themselves. The processes of dismantling, shredding and secondary processing are described in Figure 5 as the orange

hexagon labeled as “Treatment Facility”. They are all paid for by the producers at set fees regulated by the DPA-System.

2.4.1.5 Shredding

After depolluting and dismantling of the WEEE, it is shredded into smaller pieces which will later be separated. Most modern recycling facilities, the type we are most likely to encounter in Denmark, use fast rotating mills that can shred material in a fine or coarse manner depending on the settings used.

These techniques use material or particle specific properties to separate the shredded pieces. Material specific properties are those that are intrinsic to the elements that compose the pieces, like boiling point, electric conduction, etc. Techniques for material sorting include magnetic and current separation. Particle specific sorting depends on the physical properties of the shredded pieces, their size, shape, weight, etc. Techniques for particle sorting include sieving and air separation. The techniques used vary from facility to facility. In Denmark, shredding can be done in the same facility as dismantling and secondary processing or each of these steps can be done in a separate facility depending on the materials being processed or the companies available.

2.4.1.6 Secondary Processing

WEEE reaches the secondary processing stage after it has been shredded and separated. All of the components that reach this point will be recycled using material specific processes. The following is a list of recycling processes for materials usually found in WEEE (Bohr, 2007). It is important to keep in mind that WEEE is mostly composed of metals and plastics.

- Metals:
    - Ferrous Metal: Scrap steel is melted in iron smelters. First it must pass through fractioning processes that separate it from residual elements like zinc, copper, chromium and molybdenum which hinder its recycling abilities.
    - Non-Ferrous Metal: The process of recycling of non-ferrous metals is specific to metal. They are usually concentrated before their final processing and later tested for their purity. Copper smelters separate copper and other precious metals that are printed onto circuit boards.

- Glass: Glass can either be recycled back into glass, ceramic or sand. After separating the glass from the rest of the components, it is then melted and usually ends up in pellet form. Because we will mostly be dealing with consumer based electronics, no additional steps are required for glass recycling. For the material recycling, glass that contains brominated flame retardants must be separated from the rest for the melting down process to avoid contamination.
- Plastics: The recycling of plastics is complicated as it can end up in can end up in both a solid or gaseous state if is gasified as methanol.
- Hazardous Materials: They are usually recovered or processed before they reach this stage. Regardless they might still be screened for.

2.4.2 How Other Countries Deal With WEEE Management

Because of the existence of specific WEEE legislation, there are particularities of the WEEE Management process that should be taken into account when developing and researching possible models. In order to obtain a more in-depth understanding of what these details could be, we decided to look into two different examples of WEEE Management: one that falls under the EU directive and another example from Worcester, Massachusetts. After analyzing the WEEE process in the Netherlands and Worcester, MA, we have come to the conclusion that there are important similarities between them which are applicable to the Danish system.

The most striking similarity we found is the role the municipalities play in WEEE processing. In both cases, their primary role is to act as an intermediary by collecting and partially transporting WEEE to sorting and secondary processing facilities. The municipalities in the Netherlands serve as an intermediary between private contractors and the population that generates WEEE. While there are local municipal waste taxes, there are also personal taxes on electrical equipment. Households get rid of their WEEE free of charge at municipal container stations. Municipalities deliver the WEEE to regional sorting operations and are not reimbursed for any of these activities. In the case of Worcester, there are a series of municipal container stations that are open from April to November that collect a variety of recyclable waste, including WEEE. Outside of those months, you are not able to dispose of WEEE through the

municipal stations. The municipalities charge a specific amount for dropping off each type of WEEE because otherwise they are unable to cover the transportation costs. Originally they were able to accept more types of WEEE but they shortened their list because they were unable to be financially responsible for all of it. WEEE is transported to a local sorting station once collected by the municipalities. Later it is outsourced to private recycling companies which bill the municipalities based on the amount of WEEE processed.

Another important similarity is the existence of an organization that manages a variety of municipalities and is legally responsible for the overall operation WEEE collection. In the Netherlands there is an organization parallel to the DPA-System in Denmark called the Netherlands Foundation for the Disposal of Metal and Electrotechnical Products (NVMP). Similar to the DPA-System, it is comprised of producers and importers of WEEE. The NVMP creates mandates to increase the efficiency of collection in the municipalities. They also handle part of the logistics of operations and costs of transporting the WEEE. The NVMP pays the contractors per ton of WEEE transported and treated (Ministry of Environment of Cambodia, 2009). In Worcester, the Department of Public Works and Parks coordinates the residential pick up center and also coordinates with the sorting and the recycling facilities to which the WEEE is transported to.

2.4.3 WEEE Management Statistics in Denmark

In Denmark there are three ways WEEE is treated: recycling, incineration or landfilling. The majority of Danish WEEE is recycled, with 84.8% or 69281 out of a total 81730 tons collected being recycled in 2010 (DPA System, 2011b). Another 7.5% or 6135 tons were incinerated in 2010 (DPA System, 2011b). While this may seem like only a small total compared to the amount recycled, it is worth noting that Denmark is actually the country that incinerates the most waste per capita in the EU (Reno Sam and Ramboll, 2006). The remaining 7.7% or 6314 tons were either disposed of in landfills or stored to be treated later. Overall, recycling is the main WEEE treatment used in Denmark, but incineration also plays a substantial role (Figure 6).

There are many characteristics of Danish WEEE management that are worth mentioning as they distinguish Denmark from other countries under the EU directive. One of these is the

fact that the weight of electronic equipment marketed in Denmark in 2010 is almost twice the weight of WEEE collected. Bøwig, a manager at DPA-System, says that this discrepancy is likely due to some resellers and municipalities selling the valuable types of WEEE and leaving the rest to be handled by the producer compliance schemes. This means that the number of sales per year cannot be directly translated to the total waste produced the same year, even though the more electronics sold, the more waste there will eventually be. This also implies that there is currently WEEE that is not being disposed of through the established system. Yet they are being disposed in some fashion as they are not reported as ending up in landfills or incineration plants. This could mean they are either being imported illegally out of the country, recycled independently and illegally through the municipalities or being resold to distributors through the black market to be refurbished or recycled (J. Bøwig, personal communication, March 27, 2012).

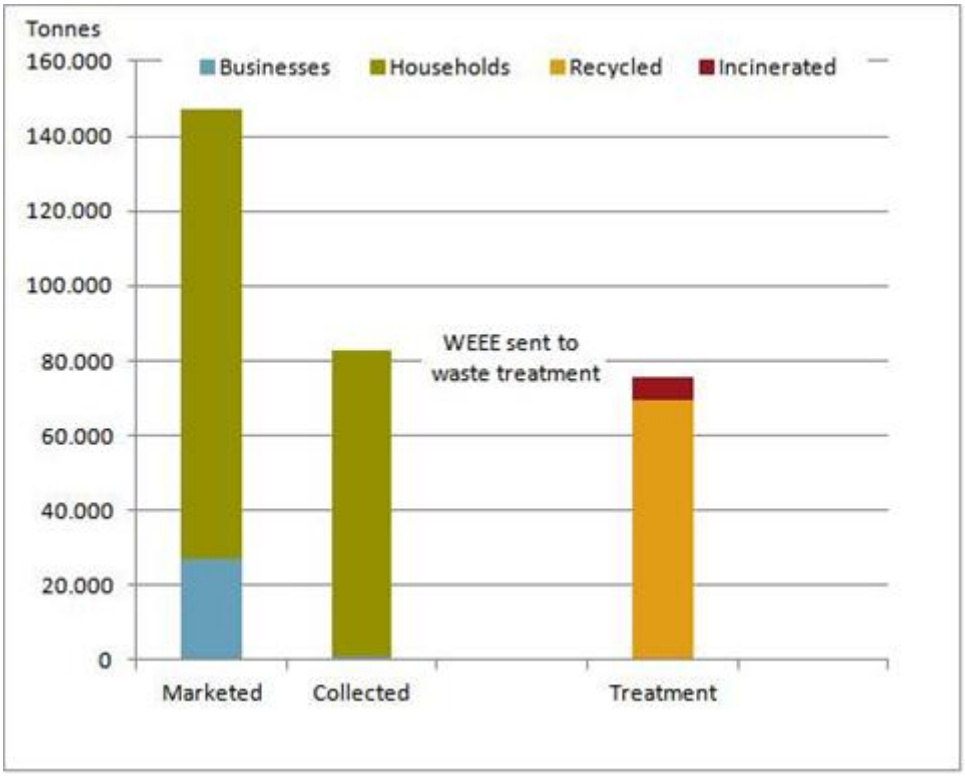

Figure 6. WEEE tonnage in Denmark 2010 (DPA System, 2011a)

It is also important to mention that regardless of losing some of the WEEE to other illegal streams, Denmark is excelling in other categories compared to other countries. Denmark

exceeds the EU's projected target goal for WEEE recycling and recovery overall and in each smaller WEEE category. Denmark has exceeded the goals for recycling and reuse set for by the EU by 5-10% (4kg of WEEE per inhabitant is the standard set forth by the directive, while Denmark currently collects about 15kg of WEEE per inhabitant) (Bøwig, 2012).

The DPA-System data indicates that the biggest amount of waste came from the large household appliances and the smallest amount of waste came from automatic dispensers such as coffee dispensers and ATMs. More than 10,000 tons of waste collected was consumer and IT/telecommunications equipment. These three categories account for more than 90% of the WEEE collected and sent for treatment in Denmark (Figure 7), and as a result should be the categories we look closest at when checking our cost calculating model.

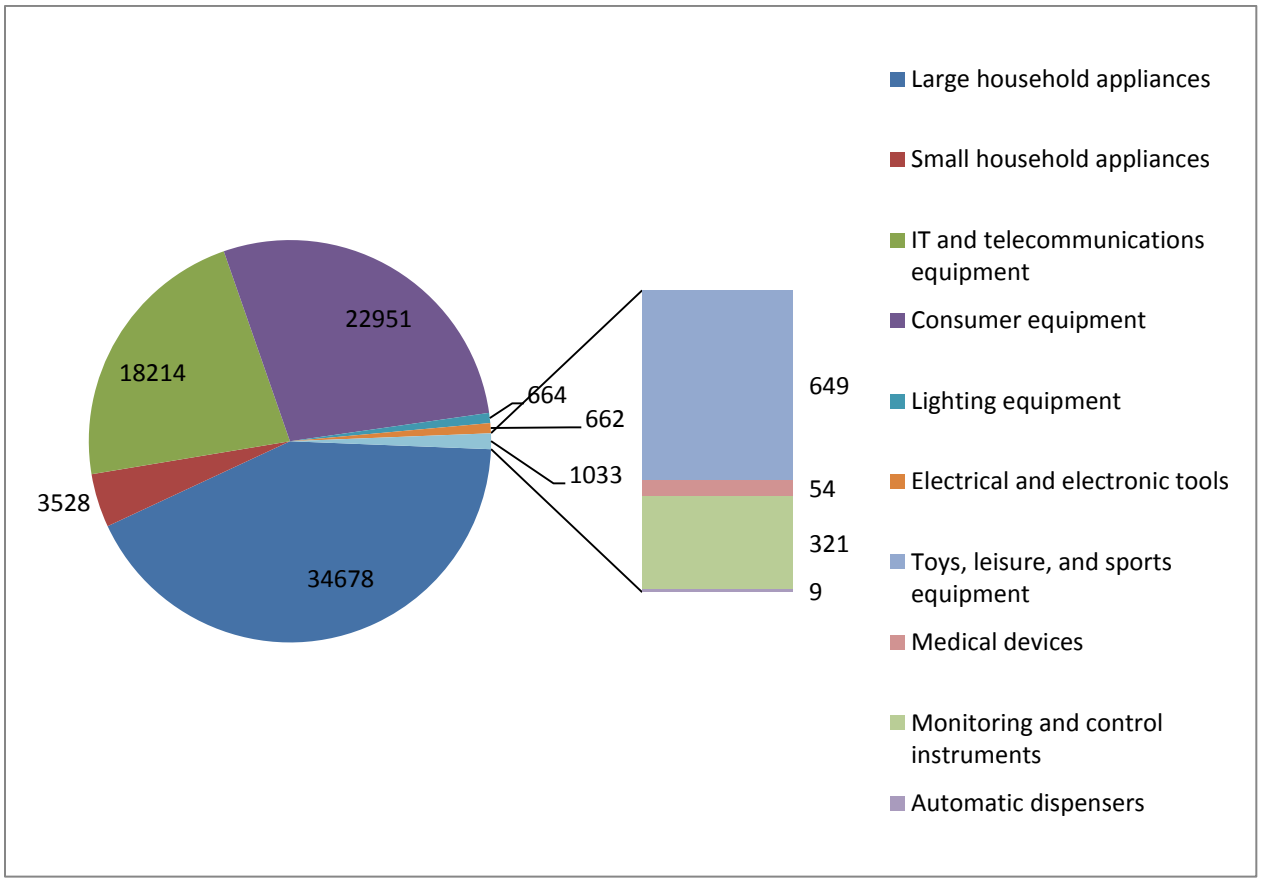

Figure 7. Distribution of tons of Danish WEEE Sent for Treatment in 2010, data taken from DPA System (2011b).

Figure 7 shows the break down for the WEEE collected in Denmark in 2010. It shows the amount of each EU WEEE category in tons. As mentioned, the largest category collected was

the large household appliances and the smallest was automatic dispensers. The current system in Denmark neglects to hold producers responsible for the costs associated with these collections. With such a high amount of products collected, the handling costs are too high to be placed on individual municipalities. Through this project, we hoped to create a cost calculating model to illustrate the costs associated with Danish municipalities' container stations.

2.5 Cost Calculating Models

For the purpose of our study, we were dealing with a cost estimation model. The purpose of a cost estimation model is to predict the expenses of a process by organizing and analyzing information on past resource expenses. These estimations are done by analyzing the activities that make up the process. The following chapter will deal with the components of our cost calculating model, which is an adaptation of the WEEE cost calculating models developed by Bohr in 2007, the NVRD in Holland and VVSG and OVAM in Belgium.

2.5.1 Cost Calculating Models

After preliminary research on costing and cost estimation models we found that the initial step in building a successful model is determining the organization and flow of the WEEE collection process in Denmark. While it is important to study the life cycle of electronic equipment to better understand the intricacies of our project, we are mostly concerned with the process of collecting the WEEE at the container stations once they reach their "End of Life".

We first had to develop a strategy for identifying the specific costs involved in the collection of WEEE. After reading through the literature of cost estimation models, we came across a strategy for identifying the necessary line items that should be included in our model. This strategy is called Time Driven Activity Based Costing (TDABC) it was developed by Kaplan and Anderson from the Harvard Business School. It allowed us to come up with a way to divide and organize the processes and expenses of WEEE collection in Denmark by dividing the overall process into two categories: resources and activities (Kaplan & Anderson, 2008). Resources are all the materials available to the municipal company to fulfill a determined objective. In the case of our model, the main resource we will be dealing with is money in Danish Kroner (DKK). Activities are the parts in the process where resources are invested. In the case of our project

our activities those involved with the collection of WEEE at the container stations, including infrastructure, staffing and administration costs, etc. They can also be called “line items” and we will use those terms interchangeably. A schematic showing this classification can be seen in Figure 8.

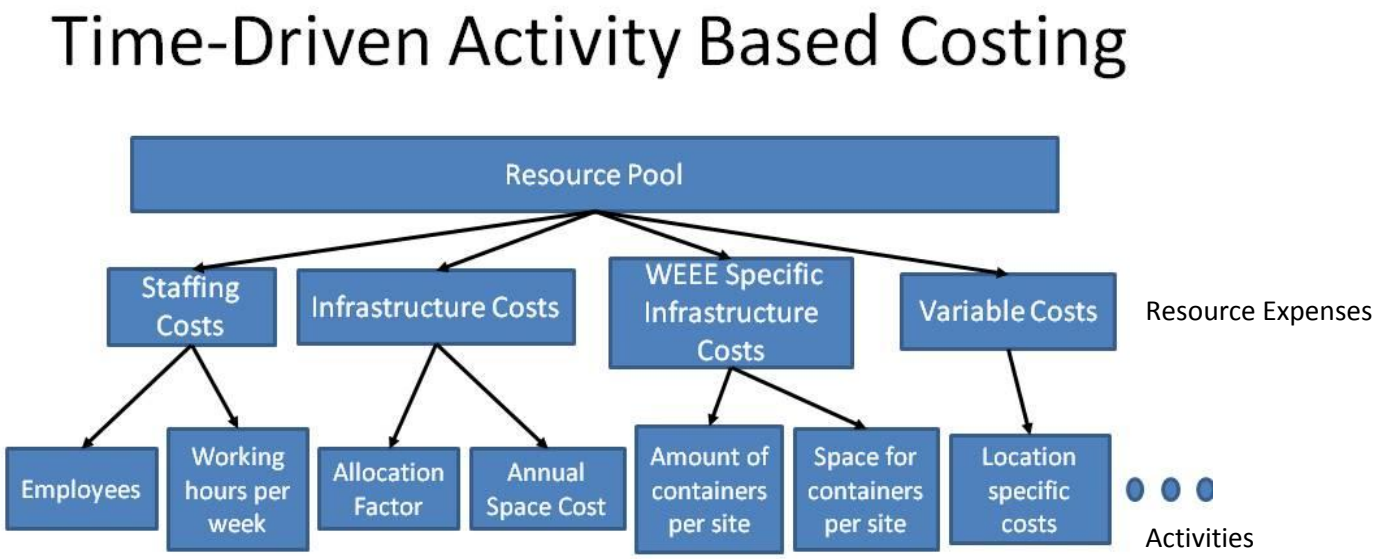

Figure 8. Resource Flow Based on TDABC Analysis

The analysis presented in Figure 8 is the first step in identifying equation variables and their units. This made it easier to create variables that can later be inserted into an equation. In the case of our model, the activities in Figure 8 were initially taken as our variables and they were organized in different subcategories depending on the resource expense which covers them. This was also a good exercise for us to think about all the possible costs associated with the collection sites. This was our initial approach to creating the cost estimation model. For the purposes of our model, we planned to enter the costs of the individual container stations into a spreadsheet and then use an equation to determine how we would allocate a portion of those costs to WEEE. The next step in our research was to find a coherent and logical way of organizing these line items to come up with a single figure that represented the costs of collecting WEEE in Denmark.

2.5.2 Bohr Equations for WEEE Waste Calculation

The most useful equation for analyzing the costs of collecting WEEE we encountered during our research was created by the economist Phillip Bohr in his 2007 thesis regarding WEEE and Extended Producer Responsibility (EPR). This model considers the principles of EPR and is able to account for the variability of costs across container stations.

The Bohr model has a different set of equations for each of the stages along the WEEE End of Life Cycle: collection, transport, sorting, depollution and treatment. Because we are only concerned with the collection costs, we will only further analyze the equations involved in this process in the following section.

2.5.2.1 Collection

Using TDABC, Bohr organized the main activities into three main resource pools: staffing costs, infrastructure costs, and WEEE specific infrastructure costs. He further broke these broad expenses into more specific activities. Some of the costs are fixed and depend on the set-up of the collection station while others vary. The equation he developed calculates the cost-per-ton (cc) of WEEE at the container stations. These equations assume that the stations are organized in such a way that their organization is as cost efficient as possible. This assumption makes the equation much simpler as it doesn't require accounting for money and time that is not directly invested in the collection of WEEE. It also would mean that the estimation provided would be an accurate representation of the true value; it is not an over or under estimation of the true cost because the station is organized as efficiently as it can so it uses the minimum amount of resources necessary to collect the waste. The following equation was taken directly from Bohr's thesis:

$$cc = vccp + \frac{\frac{fccp}{(\sum dc) * sco}}{cpd}$$

Equation 1

Where:

cc: cost of collecting per ton of WEEE ($/ton).

vccp: non-fixed (variable) cost per weight of WEEE processed. ($/ton)

fccp: fixed costs of processing WEEE per collection site ($)

dc: amount of collected WEEE (ton)

sco: Fraction collected using specific collection option (unitless)

cpd: collection point density per municipality (unitless).

Equation 1 calculates the cost of collecting a ton of WEEE. The equation divides the total fixed costs of running the container station over the total mass of WEEE processed and multiplies that by a density factor and then adds any variable costs. The fixed costs would include the line items we have discussed previously in this chapter. Variable costs (vccp) represent all other non-fixed costs that may be encountered such as special events, renovations, new constructions or unforeseen costs. The cost is highly dependent on the total volume of WEEE, which is represented by the amount per ton of collected WEEE (dc) and collection point density (cpd). The collection point density represents either the number of collection sites or the frequency of a collection option. If a municipality has 5 container stations then the container station cpd would be 5. If the municipality holds special collection events 3 times a year the special collection events cpd would be 3. The class-specific share of collection value (sco) used in the equation accounts for fractions of WEEE that are collected in different ways. This may be only at municipal container stations, through pick-up collections, or through a special event. This means that if 80% of WEEE in a municipality was collected at container stations and the rest was picked up by the municipality at certain times then the container station sco would be 80% and the pickup sco would be 20%.

2.5.3 Cost Estimation Models in Other Countries

Other countries under EPR legislation such as Holland and Belgium have created models to determine how much it costs to collect all the streams of waste at container stations. The Dutch model was developed by an organization called NVRD. NVRD is the Royal Dutch association for waste management and cleaning. It unites the Dutch municipalities responsible for waste collection and treatment. The waste handling system in the Netherlands is very similar to the one Denmark as the municipalities serve as a middle man between the producers

of WEEE and the producers that treat the waste for collection. We were keen on studying their methods for allocating the costs of WEEE and also what line items are included in their model.

Belgium is another country that has created a successful cost calculating model. This model was developed in a joint collaboration between VVSG and OVAM. VVSG is the Association of Flemish Cities and Municipalities and OVAM is the Public Waste Agency of Flanders. These two organizations are comprised of municipalities and Flemish communes. OVAM specifically deals with waste management and soil remediation. These two organizations created a cost model for calculating the cost of waste collection at container stations throughout Belgium. This model is a web based survey in which municipalities or individual container stations can gain access for a subscription fee dependent on their needs. It was interesting to study their WEEE allocation system and the costs considered in this model since Belgium is also under the EU directive.

Chapter 3: Methodology

The purpose of this project is to create a cost calculating model for handling Waste from Electronic and Electrical Equipment (WEEE) at Danish municipal container stations. This model will be used to lobby for full cost recovery as seen within the European Union Directive on this topic, which puts financial responsibility on the producer and should lead to more ecologically aware product design. This project relies on feedback gathered from Danish intermunicipal waste companies, as well as a study of similar cost estimation models developed in other countries and interviews of stakeholders involved in order to create an effective final deliverable. Throughout this section, when we refer to the "model", we refer to the combination of the survey excel spreadsheet and the calculations used throughout that sheet to calculate a final cost.

The objectives for the methodology section of the project were as follows:

- Develop an initial model based on reviewed literature as seen in the background chapter
- Review and analyze the NVRD (Holland) model and the VVSG (Belgium) model on site to refine our initial model
- Choose a representative group of Danish intermunicipal waste companies to survey through a sampling strategy
- Visit some municipal waste companies, get recommendations on the model and survey their costs
- Refine model and use it to collect costs from a larger number of municipal companies
- Obtain input on the fairness and transparency of our model from stakeholders

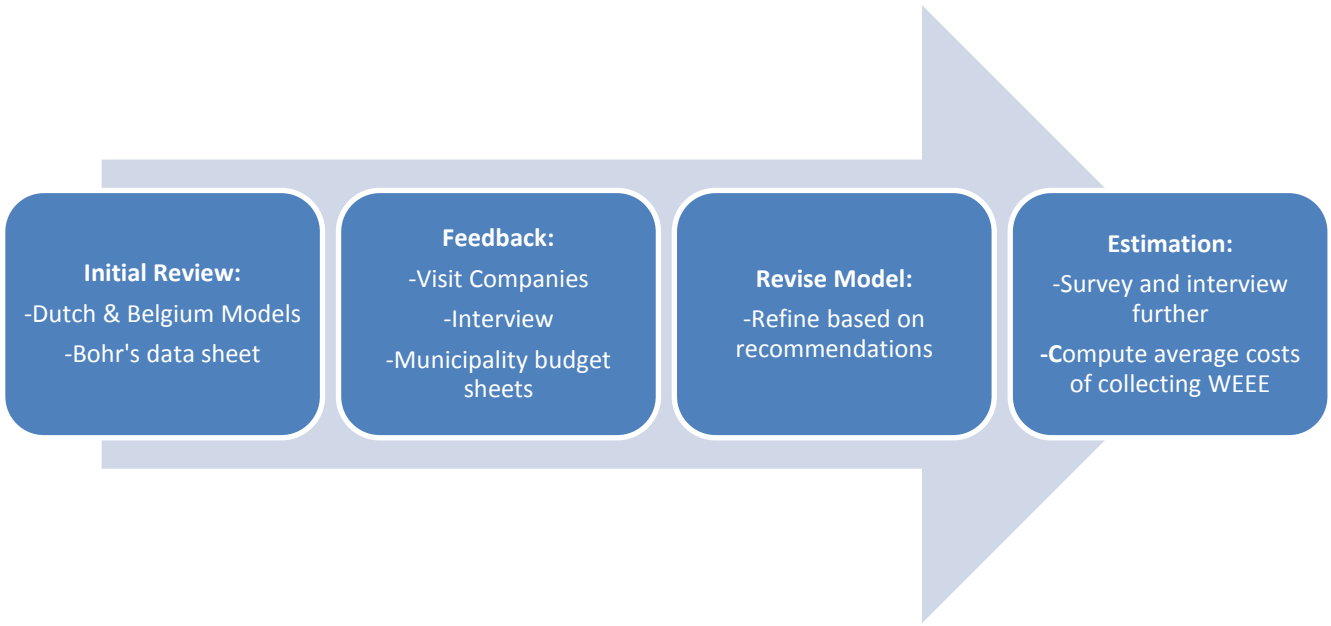

Figure 9. Summary of Methodology

Figure 9 illustrates the process we went through when designing and refining our model to come up with a deliverable that satisfied our goals. First we examined cost calculating models through research done prior to arrival to the site and developed a preliminary list of line items as well as an equation for data analysis. While on site, we researched models created by NVRD in Holland and VVSG in Belgium. To see if we had overlooked any costs, we visited a sample of municipalities to interview waste company managers about our line items and reviewed their budget to check for the costs they already record. With the information we received from the stations and other models, we revised our initial line items into a spreadsheet that was relevant, accurate, and easy to understand. We used the final spreadsheet as a survey collection tool to solicit data from additional municipal companies and used our analysis equation to compute an average cost for our representative sample categories and the country as a whole.

3.1 Initial Review

We performed an initial review of three different models. The first we reviewed was Bohr's data collection sheet. This was a general sheet that provided us with the basic understanding of what line items a model for WEEE should include. We then examined the Holland and Belgium models by looking at what costs they included and how they calculated

these costs. Both models went into further depth than the Bohr model on collection section. Our initial review of these three models gave us an understanding on what items needed to be included in a cost calculating model. By looking at each line item that they included and trying to relate it to the Danish system, we developed an initial model, which would be further revised after gaining feedback from municipal companies. Further explanation of these initial line items can be found in Chapter 4.1 of the Results section.

3.2 Feedback on Our Initial Cost Items

To refine our list of line items for the collection of WEEE, we decided to visit municipal companies and their individual container stations. We obtained their budgets and adjusted our model so it contained costs the municipality is already collecting. We sent them a revised survey sheet and asked them for data on these costs. We devised a sampling strategy to choose a variety of municipal company to visit since costs may vary across them and we could not visit them all. After choosing and contacting three different municipal companies, we planned site visits to discuss our model and collect on-site costs. From that information we were able to refine our model.

3.2.1 Municipality Sampling Strategy

In Denmark there are 392 container stations, also known as collection sites, within 98 municipalities. Some municipalities have joined together to form intermunicipal waste companies, while some larger municipalities have multiple waste companies within them. Due to time constraints we were unable to interview and sample costs from all container stations or all municipal companies controlling them, so we decided to get feedback from principally from three municipal companies instead. We categorized all municipal companies based on the amount of WEEE collected in the previous year and the average population served by their municipalities' container stations. Information was readily available from the DPA-System's 2010 Annual WEEE Report online and came be found in Appendix A.

Table 1. The Six Criteria Used to Categorize Municipal Companies

Category	Tons/Site
Low WEEE	<200
Medium WEEE	200<x<400
High WEEE	>400

Subcategory	Thousand Inhabitants/Site
Small population	<20
Medium population	20<x<60
Large population	>60

Table 1 shows the two main factors we used to categorize the municipal companies; the amount of WEEE they collect and the size of the population they serve. First we divided the companies into those that handle low amounts of WEEE (less than 200 tons per site), medium amounts of WEEE (between 200 and 400 tons per site) and higher amounts of WEEE (more than 400 tons per site). We then determined the average population served per station in the various municipalities by dividing the number of inhabitants in each municipality by the number of container stations. We labeled municipalities with less than 20,000 inhabitants served per site as small, between 20,000 and 60,000 inhabitants served per site as medium, and more than 60,000 inhabitants served per site as large. Appendix C examines the process we used to sort the data on municipalities and then categorizes them.

By using this method, we have a good idea about the number of people served in a municipality and the relative size of the stations. We assumed that the more WEEE that is collected, the larger the facilities are. Similarly, we assumed the higher the number of people in the area, the busier that stations would be.

Table 2. Municipality Categories

Number Assign.	Category	Subcategory
1	Low WEEE	Small population
2	Low WEEE	Medium population
3	Low WEEE	Large population
4	Medium WEEE	Small population
5	Medium WEEE	Medium population
6	Medium WEEE	Large population
7	High WEEE	Small population
8	High WEEE	Medium population
9	High WEEE	Large population

We proceeded to select intermunicipal companies from which we would collect data from. Initially, we decided to look at three companies from different category numbers to interview and present our preliminary model. From our list of categories and a discussion with RenoSam about which member companies are easiest to cooperate with, we decided on visiting Reno Djurs, Horsens Kommune, and Forsyning Helsingør A/S (categories 1, 4, and 9 respectively). These companies represent areas with container stations that serve different size populations and that handle different amounts of WEEE. A list of all the RenoSam member companies and their category numbers can be found in Appendix D.

3.2.2 Surveying the Intermunicipal Companies

We obtained cost information to test and revise our spreadsheet from the intermunicipal companies listed above. Before visiting the municipal companies, we sent our preliminary spreadsheet to a contact person at the company's headquarters and explained our project. This allowed the person to prepare for our visit and have some costs ready for our survey. We also asked for their previous year's budget or accounting sheets before our visit. Because our unit of analysis is the intermunicipal company, we collected data for all of their container stations together. During our visit, we made notes on which data we could easily

collect and which items were more difficult. Any additional costs not anticipated were added to the datasheets as well. This trial allowed us to then revise the spreadsheet.

We then attempted to collect cost information from an additional seven municipal companies via a revised email survey. Due to our time constraints, we could examine only as many companies of those seven companies that responded before our deadline. From this information and using our model, we were able to create estimations for the municipality's total cost to collect WEEE.

3.3 Obtaining Input on Fairness on Our Model

In order to make our model as fair and transparent as possible, we obtained feedback from the different stakeholders involved in the WEEE collection process. Besides the municipal companies, these stakeholders include: the DPA-System, a producer scheme, and the Danish Ministry on the Environment (EPA). By asking these stakeholders questions regarding EPR, the current WEEE collection system and their role in it, we had a better understanding of the problems in the current system in Denmark and how a new legislation forcing producer to pay for collection costs could alter that system. The insights we gained from these interviews are presented as recommendations in a later chapter of this report.

We conducted interviews before our model was complete. We first decided to talk to a representative from the DPA-System since they have been in charge of implementing EPR in Denmark since the EU Directive first came into effect in 2007. The objective of this interview was to obtain a more accurate understanding on how EPR is currently implemented in Denmark and the difficulties they have found in implementing it.

The other set of interviews were conducted after we obtained preliminary data for our model. Our interview questions were heavily based on the results and changes done to our model based off previous visits and discussions. Once the model was complete, we asked both a producer scheme and the EPA questions centered on EPR, their thoughts on what constitutes a fair model, and more in depth questions about specific costs associated with collection. This helped us understand what both parties deem fair and allowed us to develop a concrete set of recommendations as seen in a later chapter of this report.

3.4 Finalizing the Model

Our finalized model is an easy to use survey in the form of an Excel spreadsheet that calculates accurate and transparent costs for collecting WEEE at the intermunicipal companies and an adapted version of Bohr's formula. By making all the costs transparent, the debate becomes less of a philosophical one and more of a line item analysis. This model accounts for the wide variety in Danish intermunicipal companies as well. It can be used at any municipal company to calculate the cost of collecting WEEE. The final model can be seen at the end of Chapter 4 on results.

3.5 WEEE Collection Cost Estimation

In addition to our spreadsheet, we planned to develop a more accurate estimation for the cost of WEEE collection in Denmark using our adaptation of Bohr's Equation. In order to find an average cost for the varying container stations, we planned to examine Bohr's equation and adapt it and its variables so it relates to our particular project. We would then be able to use the data collected and this equation to formulate average costs per category and for the country as a whole. Our realizations on Bohr's model and our estimations can be seen in the Results chapter.

Using the information on the spreadsheet and the equation we develop, we aimed to come up with numbers for average collection costs within the different intermunicipal categories. These costs would be calculated per ton of WEEE collected and per inhabitant the intermunicipal company serves. With these averages, we would calculate an average WEEE collection cost per inhabitant in Denmark in order to calculate a total WEEE collection cost for Denmark.

Chapter 4: Results

Throughout the course of this project, we obtained six main results: our initial line items based on our review of the literature, a revised spreadsheet based on the NVRD and VVSG models, a refined spreadsheet with clear instructions based on feedback from site visits, a finalized model including the final spreadsheet and calculations, recommendations on how to implement this model based on stakeholder interviews, and an estimate for the total cost per ton for the collection of WEEE based on data obtained from 5 waste companies. This section will look at these results in detail.

4.1 Initial Line Items

Before we arrived in Denmark we found three separate costs associated with the overall total fixed costs for WEEE: staffing costs, infrastructure costs, and WEEE specific infrastructure costs. We broke these down into line items that we planned to put in a spreadsheet in order to survey container stations. The items that would be imputed into the spreadsheet are shown as in Figure 10.

FCC: Fixed Collection Costs

WEEE Specific Waste

WEEE collected	*Total tonnage of WEEE collected*	ton	
Total Waste Collected	*All wastes collected*	ton	
Allocation Factor	*percent of WEEE out of total*	%	

Staffing Costs

Employees		#	
Working hours per week		*hrs/week*	
Weeks per year		*weeks*	
Annual working hours per employee		*hrs/employee/year*	
Labor Cost per hour		*DKK/hr*	
Allocation factor	*WEEE collected/total waste collected*	%	
Total Annual WEEE Related Staffing Costs			

Infastructure Costs

Office and social rooms	*Area*	*m^2*	
Annual rent for offices and social rooms	*Cost per area*	*DKK/m^2*	
Annual cost offices and social rooms		*DKK*	
Annual cost handling equipment (forklift)	*Forklift…*	*DKK*	
Annual cost infrastructure and maintenance	*Fences, locks…*	*DKK*	
Other operating costs	*Office equipment, energy, water…*	*DKK*	
Access routes	*Area*	*m^2*	
Switching space	*Area*	*m^2*	
Additional drop-off area	*Area*	*m^2*	
Annual space rental per m2	*Cost per area*	*DKK/m^2*	
Annual space cost		*DKK*	
Allocation factor	*WEEE collected/total waste collected*	%	
Total Annual WEEE Related Infastructure Costs			

WEEE Specific Infastructure Costs

Amount of containers for circling	*Number*	*units*	
Depreciation period	*How often replace*	*years*	
Cost per container		*DKK/unit*	
Annual container cost		*DKK*	
Space per container	*Area of container*	*m^2/unit*	
Annual space cost per m2	*Cost per area*	*DKK/m^2*	
Amount containers on site	*Number*	*units*	
Annual space cost container area		*DKK*	
Total Annual WEEE Specific Infrastructure Cost			

Total WEEE collection cost per station	

Figure 10. Preliminary Line Items Adapted from (Bohr, 2007)

We planned to enter the total cost of WEEE per station into the analysis equation we developed from Bohr to estimate the cost of WEEE collection in Denmark as a whole. During

our preparation stage before arriving in Denmark, we simplified the original equation Bohr developed to an equation that was easier to understand and work with. However, when arriving on site in Denmark and reassessing the usefulness of this equation in our project, we decided on eliminating it. This is because of the wide variations within the container stations from the same intermunicipal company. We originally thought that we would work under the assumption that the stations were not significantly different, but upon site visits, we realized this would not be an accurate means of estimation. We would later develop a different means to estimate the total collection costs of WEEE and this can be seen in section 4.6 of this chapter.

4.2 Revised Spreadsheet from Other Models

Once we arrived on site, we obtained the cost calculating models created by the Royal Dutch association for waste management (NVRD) and the Association of Flemish Cities and Municipalities (VVSG). These models broke down their line items into detailed questions, included additional cost categories, and determined the amount of the total costs allocated to WEEE based on factors other than weight. We revised our initial list of line items by adding items that we had not considered but were included in these other models.

4.2.1 NVRD Model in Holland

The cost calculation model set forth by NVRD in Holland included a spreadsheet with a list of operating and initial investment costs (NVRD, 2006). In that model, the spreadsheet was used to survey different container stations. We used this idea in revising our spreadsheet so that it could be sent out to intermunicipal waste companies.

We translated the NVRD Model to English and then examined the setup of its spreadsheets. We created three similar sheets to describe the different economic factors that we must take into account. We ignored line items that we felt were not relevant, such as data on non-WEEE waste streams, and included other line items we felt were necessary from Bohr (2007). Many of the items that the NVRD model contains are relevant to container stations in Denmark, though we planned on visiting container stations to validate this notion. The NVRD model looks at all waste streams, while our project aims to determine the costs of just WEEE as compared to all non-WEEE waste.

We looked at the NVRD model to create a set of three spreadsheets which would be used for surveying and calculating costs. The first sheet was a survey sheet which would be used to obtain basic information from the municipal companies we visited. The survey sheet had seven categories: general information, staffing costs, land and building areas, initial infrastructure costs, equipment costs, operational infrastructure costs, WEEE specific infrastructure costs, and a WEEE allocation factor. Under each heading was a list of costs from the Holland model we determined would be relevant at a Danish container station. The second and third spreadsheets examined operational and infrastructure costs. The information on specific quantities from the survey sheet would be pulled and multiplied by predetermined average unit prices to calculate costs for each line item. The line items would be summed to find subtotals under different cost categories. These three spreadsheets can be seen in Appendix E of this report.

We later found that this initial approach of finding detailed costs for line items using average unit prices multiplied by quantities gathered from a survey sheet was unnecessary and seemed would put a burden on administrators filling the sheet out. We would later simplify this by asking only for total costs for staffing, maintenance, etc as explained in section 4.3 of this chapter.

4.2.2 VVSG Model in Belgium

VVSG and OVAM, two organizations from Belgium, created a model for calculating the cost of waste collection at container stations throughout Belgium. This model is a web based survey in which municipalities or individual container stations can gain access for a subscription fee dependent on their needs. The model (VVSG & OVAM) examines very specific areas of the container station, including investment costs, operational costs, external funding, and staffing costs. Similar to the NVRD model, it asks questions about particular areas and their unit costs and quantities. It is very specific in its analysis.

The model determines how much cost is allocated to WEEE by considering several factors, not just weight: weight, homogeneity of the waste stream costs, frequency of drop offs, and useful surface area. It also gives the user the ability to weight the importance of these factors. Much like the NVRD model, the VVSG model does not say which method of calculating

the allocation factor is best, but simply offers the option to use various methods. After looking at the VVSG model we decided to include an allocation factor based on time spent dealing with WEEE. This allocation factor would be later revised after site visits and discussions with waste management companies.

4.3 Input from Site Visits

As explained previously, we chose three municipal companies (Helsingør, Reno Djurs, and Horsens) to visit and discuss any shortcomings in our model. These stations varied in size and amount of WEEE collected (they fell into three categories out of the nine we established earlier). We emailed the companies a copy of the survey sheet portion of our model and then met with them a few days later to discuss what they thought of the survey sheet. From these interviews, feedback was collected and further revisions to the model were made. We did not collect final numbers from them until the survey sheet was finalized.

4.3.1 Helsingør Interview

The first company we visited was Forsyning Helsingør, one the largest intermunicipal companies in Denmark. It is the only category 9 on our list of intermunicipal companies which means it processes among the greatest tonnage of WEEE and has the highest ratio of population served per container station of all the municipalities.

Before arriving to Helsingør we obtained their 2009 budget. This budget was translated to English and compared to our spreadsheet. If our spreadsheet's line items were relevant they should have resembled those present in the municipalities' budgets. We wound up removing many line items since they were not included in the budget and would be hard to determine. For example, our spreadsheet had asked for staffing salaries, training, clothing, overtime, pensions, and miscellaneous costs but the company simply reported a total cost for staffing on its budget, so we revised and simplified our spreadsheet to do the same. It was this revised version which we sent to Helsingør before we visited them.

When we arrived in Helsingør we asked Lotte Rahbek, a company representative, if they had a more recent budget, but learned that the 2011 budget was not available due to technical issues. We were told that the differences between different years were minor and

would not significantly affect the total numbers. Therefore to calculate the collection costs for Helsingør we used the 2009 numbers.

We also obtained feedback on our spreadsheet. We learned that we should add some instructions to our survey to make it easier to fill out. We learned that we would need to estimate and include the cost of curbside collection. We initially placed it under the miscellaneous section because not every municipality in Denmark provides curbside collection, but we found that it was such an important cost that it had to be listed separately. For example, Helsingør's cost for curbside collection of bulky waste (including WEEE and other waste) was 1,665,00 DKK, a significant fraction of the container station's 20,111,000 DKK of expenditures.

We also found that calculating just the specific costs for WEEE collection as opposed to other waste streams was more complicated than we anticipated. For example, in curbside collection, WEEE is not collected separately from other types of waste. Because of this we needed to estimate the percentage of curbside collection costs that WEEE contributes to. We were told by a representative of Forsyning Helsingør that WEEE accounts for 5 to 10% of the cost for bulky waste curbside collection.

We also learned that the actual cost of collecting WEEE might be higher than what we would calculate if we used weight as the only allocation factor. This is partially because stations collect waste in containers that hold a specific volume of WEEE, but potentially different weights depending on how compact the container is packed. This leads to a conflict with the intermunicipal companies that come to collect these containers. If they are not completely filled up, the producer schemes will complain that they are wasting transport money on unfilled containers. In order to effectively fill up the containers, the employees must devote more time to WEEE than they would with other waste streams by doing activities like carrying heavy computer screens, packing the white goods as effectively as possible, etc. Therefore, volume could be used as a measure of how effectively the employees work as it measures how packed the containers are.

She also mentioned that this increased time spent on WEEE also resulted from the need for increased security in the facilities since WEEE contains valuable raw materials. WEEE is usually locked away at night in response to attempted thefts. It requires employee time to

move the WEEE and it costs money for the container stations to the security systems, locks, etc. After this conversation, we decided to consider calculating the percent of total waste costs that is specific to WEEE based not just on weight on volume, or time employees spent working with the different types of waste.

4.3.2 Reno Djurs

Reno Djurs was the second company we visited to obtain feedback on our project. Reno Djurs is an intermunicipal waste management company that collects waste for the Norddjurs and Suddjurs municipalities on the East coast of the Jutland peninsula. It is considered a category 1 intermunicipal company, meaning it is less densely populated and its container stations collect less tons of WEEE per year. The company has a total of 9 container stations: 3 bigger ones and 6 smaller ones. They only collect WEEE through these container stations; there is no curbside collection.

We sent them our initial survey, which they partially filled out and returned to us. They also sent us their 2011 budget, which we used for redefining our line items and simplifying our model. Their budget was compared with the Helsingør budget to identify any differences and similarities. We redefined our model so it would mimic the budget these municipalities already collect.

We interviewed Peter Madsen from Reno Djurs to obtain feedback for our model. Our topics of conversation were heavily based on the problems we identified at Helsingør. We looked to obtain feedback primarily on the allocation factor. We originally only considered the weight of WEEE versus the weight of the other waste streams. We realized this would not be the most precise or fair allocation factor because of the special characteristics of WEEE, such as the difficulty of fitting differently sized WEEE into one container without overflowing or falling through the bottom of the containers if they are small WEEE (cell phones, chargers, etc). After studying the Holland and Belgium model again, we approached Reno Djurs with the idea of creating a weighted average between three factors: time, weight and volume. Of these three factors, he stressed the importance of time. By asking employees at their container stations, he calculated that about 10% of the hours open per year are dedicated to activities that only pertain to WEEE.

There were other minor topics touched upon. We asked him how easy it was to fill out the Excel sheet and if he thought we needed instructions. He said that he simply forwarded the model to an employee in the finance department and they seemed to have no problem filling it out. He said the Excel spreadsheet was straightforward enough in itself that instructions were not needed. He also mentioned that it would be extremely hard to calculate the municipal governmental costs but that those costs were insignificant anyways. He mentioned that there should be a section for administrative costs. He also stressed on the importance of keeping the WEEE safe from theft by locking them in deposits at night.

4.3.3 Horsens

The last municipality we visited was Horsens. Horsens differs from the other two companies in that it is not a company but rather a division of the municipality government. It is a public cooperation overseen by workers employed by the local government. They have 4 container stations and serve about 50,000 people. They were currently in the process of building a new storage/container area for WEEE in one of their container stations.

We met with the director of the waste and recycling section and the head of the landfilling and recycling division within that section. We went through the same process of acquiring their budgets and adjusting our model as we did with the other two municipalities. In the end we sent them our most recent model and asked them for their feedback on the same topics as Reno Djurs.

We obtained similar feedback from Horsens regarding the subjects of allocation. They agreed with Reno Djurs that time was an important factor to consider when allocating the costs of WEEE. They estimated that they spend a maximum of 10% of their total hours open a year on WEEE. They also agreed with Reno Djurs that the overall municipal legislation costs are minimal and don't necessarily need to be included in the model. They also didn't find further instructions to be necessary to fill out the Excel sheet but would have appreciated a comment box to remark on the numbers they provide.

4.4 Finalized Model

Our finalized model is an Excel spreadsheet that contains the survey spreadsheet for the municipal companies to fill out as well as the computational formulas for calculating the total

cost of collection of WEEE. We break down our spreadsheet and analyze the different sections in this section.

Below we break down our final survey sheet and analyze its different components. Municipal companies can use this to fill in total costs for all their container stations and the allocation data to identify what costs are due to WEEE collection. The spreadsheet is designed in such a way that it could be used to collect data from an individual container station, but due to time and reality of what the companies record, we collected data for total intermunicipal company costs. Some of the headings listed throughout have been translated to Danish with the assistance of our liaison for clarity. The person filling out this sheet inserts values into the orange boxes on the right. The questions are in bold font on the left. Some questions suggest items to consider when figuring totals for each category. After each section there is a comment box that allows the person filling out the survey to comment about any of the questions asked, whether they had trouble finding any of the costs or if they included other costs that did not appear on the list. The spreadsheet is locked so that the person filling it out will only be able to input data in these two types of boxes. The gray boxes on the right and under each major heading are totals calculated by Excel. These totals are calculated from the numbers plugged into the orange boxes.

In the spreadsheet section seen on Figure 11, we ask for some general information pertaining to the container stations' hours and population served. It gives us an idea of how many people visit these sites. This data is useful for statistical as well as analytical purposes. The number of residents and container station users can be used to calculate the cost per person the same the tons of WEEE can be used to calculate cost per ton collected. While we will not be using this data in our project, we decided to include it in our spreadsheet as because it could be useful for further studies.

Survey to Calculate Past Year's Collection Costs for WEEE

The goal of this survey is to collect the total costs of handling waste at all container stations in your intermunicipal waste company. This information will be used to estimate the cost of collecting WEEE and to lobby for legislation that would require producers to take financial responsibility for the collection costs.

Please enter totals for all your container stations in the orange. Base the numbers outon of the most recent and complete budget you have available.

Questions or comments may be directed to Niels Remtoft of RenoSam at Phone: 46 74 01 13 or nir@renosam.dk

General Information

Number of Container Stations in Company?	Number	
How many residentse are regsitered to use the container stations under your management?	Number	
How many residents in total visit the collection stations each year?	Number	
How many hours per week are all the container stations in your company in operation?	Hours	
Comments on the questions or your answers?		

Figure 11. General Information

Figure 12 shows the section on the WEEE Allocation Factor. It determines the percentage cost that is due to WEEE. This percentage is based on three factors; weight, volume, and time. Weight is just the weight of WEEE collected divided by the total weight of all the waste streams. We have standard densities that we use to calculate the volume of each waste stream. These values have been adapted from the NVRD model and have been confirmed in our site visits. They represent how densely packed each container is. Because the producer schemes collect WEEE in the containers that have a very specific volume, it is an important factor to calculate. Producer schemes can use the volume, divide it by the volume of their containers, and calculate how many containers they should be filling and compare it to the actual number. To calculate the percent of WEEE by volume we first find the volume of each waste stream by dividing its weight by the given densities. We then divide the volume of WEEE by the total volume of waste collected. The final factor we look at is time. Time is important because workers often spend more time dealing with WEEE compared to other wastes. To calculate this percentage we suggest they examine the number of hours spent a week guiding people, cleaning, handling, and talking about WEEE out of the total number of hours the facilities are in operation. We decided on these three factors as a result of our interviews with

municipal companies. If you look at the percent of WEEE based on each of those factors separately, you can see how they may be vastly different. To address this we asked the companies to rank how important they feeleach factor was in terms of WEEE costs. From this, we developed a standard weighted average as seen in figure 13.

WEEE Allocation Factor (WEEE Tildeling Faktor) *Please report how many tons of waste you collect in each waste stream you collect:*		Amount Collected	Density (tons/m3)	Volume (m3)
WEEE	Tons		0.2	**0**
Accumulators (Car Batteries)	Tons		0.8	**0**
Asbestos	Tons		0.3	**0**
Concrete and Brick	Tons		1	**0**
Landfill	Tons		1	**0**
Tires	Tons		0.1	**0**
Commercial Recycling	Tons		0.2	**0**
Hazardous Waste	Tons		0.05	**0**
Bottles and Glass	Tons		1	**0**
Gypsum	Tons		0.5	**0**
Glass with Frames	Tons		1	**0**
Garden Waste	Tons		0.2	**0**
Hard Plastic	Tons		0.2	**0**
Rigid PVC	Tons		0.2	**0**
Impregnated wood	Tons		0.25	**0**
Iron and Metal	Tons		0.5	**0**
Cable and wires	Tons		0.2	**0**
Clinical Risk Waste	Tons		0.05	**0**
Paper and Cardboard	Tons		0.05	**0**
Plastic "cling" wrap	Tons		0.05	**0**
Clean soil	Tons		0.2	**0**
Combustible	Tons		0.2	**0**
Gas Cylinders	Tons		0.2	**0**
Clothing and shoes	Tons		0.05	**0**
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Totals		--		--
Weight Allocation			--	
Volume Allocation			--	
Comments on the questions or your answers:				
How many total hours are all of your container stations open a week?	Hours			

How many hours do you spend on WEEE a week for all container station?	*Including:* *Guiding people to WEEE containers* *Cleaning WEEE* *Handling WEEE containers* *Operators talking about collecting WEEE*	Hours	
What percentage of time would you estimate employees at the stations spend on activities relating to WEEE?		%	--
Comments on the questions or your answers:			
Time Allocation			**--**

Figure 12. Allocation Factor

This section on the weighted average calculates how much of each allocation factor to include in the overall WEEE allocation factor. The development of this allocation factor was based on the allocation factors used by the Belgium and Holland models and the result of the different interviews done to the stakeholders involved. In the survey we sent to the 5 companies, it asks to give a qualitative rating of the importance of each factor, which we then use to assign percentages based on their responses. The default percentages for the weighted averages were calculated based on the responses to our survey questions about the importance of weight, volume, and time and are shown above in Figure 13. All 5 responders gave similar answers to the questions. They said that weight was least important and that time was slightly more important than volume. We chose the percentages (20% for weight, 35% for volume, and 45% for time) as a way to numerically represent these answers. In the final spreadsheet,ok good—clarify earlier—see my confusions above and try to rewrite this section intermunicipal companies will be given two options: to either change these percentages or keep them as they are. The percentages can easily be changed if the factors need to be weighted in another way. To calculate the overall allocation factor we take each individual allocation factor (results of weight, volume, and time), multiply them by their corresponding percentage, and add them up to get a weighted average for the overall allocation factor. This number is used to find the percentage of the total operating cost that is actually spent on WEEE.

Weighted Averages (Wighted Gennemsnit) *We are considering several methods to calculate the percentage of total costs that WEEE is responsible for. Please tell us how important you think various factors are (for example: very important, somewhat important, not important at all)*		
The factors include:	(weight of WEEE collected) divided by (weight of all waste collected) (volume of WEEE collected) divided by (volume of all waste collected) (staff time spent on WEEE) divided by (total staff time)	Percent
How important is weight?		**20%**
How important is volume?		**35%**
How important is the time dedicated to WEEE at the stations?		**45%**
Comments on the questions or your answers:		**100%**
Overall WEEE Allocation Factor		**--**

Figure 13. Weighted Average

The following sections are costs shared with other waste streams. They are the cost to operate and maintain the facility as a whole, for all waste streams. When multiplied by the overall WEEE allocation factor, you obtain the costs of running the facility that are due to WEEE collection.

Staffing Costs (Personaleudgifter) *The costs associated with staffing the collection stations throughout the year*			
Suggested items to consider:	Salaries Training/Education Clothing Overtime Extra Additional Monetary Benefits Consultants Pensions Miscellaneous		
Total Staffing Costs		DKK	
Comments on the questions or your answers:			
Real Estate Costs (Ejendomsmæglere Omkostninger) *The annual amount you pay on rent or mortage on the collection station facilities:*			
Real Estate rent/mortage		DKK	
Comments on the questions or your answers:			
Maintenance *The annual cost of maintaining the collection station facilities*			

Suggested items to consider:	Landscaping Green Areas Paved and Impervious Areas Fencing Gates Signs and Road Markings New construction of Permanent Buildings Oil/Grease Separator Maintaining Hazardous Waste Area Maintaining Reception/Office Area Cleaning Miscellaneous		
Total Maintenance Costs		DKK	
Comments on the questions or your answers:			

Equipment Costs (omkostninger til udstyr)

The total costs of purchasing/renting/maintaining equipment necessary for collection waste this past year

Suggested items to consider:	Buying, Renting, and Maintaining Wiring and Barriers Equipment Insurance Containers Tools Fixtures Computers Cars Scales Shredders Forklift CCTV and Security System Miscellaneous		
Total Equipment Costs		DKK	
Comments on the questions or your answers:			

Utilities

The annual costs of the utilities to run the collection stations facilities

Suggested items to consider:	Electricity Gas Diesel Water Heating Telephone Internet Website Domain Miscellaneous		
Total Utilities Costs		DKK	
Comments on the questions or your answers:			
Total Waste Shared Costs			--
Subtotal WEEE Costs (with Allocation Factor Applied)			--

Figure 14. Shared Costs

Fig 15 shows the part of the spreadsheet section for miscellaneous and WEEE specific costs. The bulky waste (curbside collection) is an estimated amount that examines the total cost to collect these kinds of waste and what estimated percent of that is WEEE. This was not included in the previous section because not all intermunicipal companies offer this service, and if they do, it is usually either exclusive to WEEE or shared only with bulky waste (like sofas, chairs, etc). This cost is calculated by multiplying the estimated percent of WEEE by the total cost of the collection. The WEEE specific cost gets added to this amount to find the subtotal WEEE specific cost. Finally the total WEEE collection cost is found by adding the two subtotals (shared cost after the allocation factor is taken into account and WEEE specific cost). All of these costs can be seen above in Figure 15. For the full final spreadsheet, please refer to the files attached to this document.

Bulky Waste Collection Costs
(Storskraldsordninger)

If you collect WEEE through curbside collection, please provide the total of the following costs

Suggested items to consider:	Transportation vehicles		
	Gasoline and fuel for the vehicles		
	Employee costs		
	Logistic and planning costs		
Total Bulky Waste Collection Costs		DKK	
What percetage of your bulky waste collection do you estimate is WEEE?		%	
Comments on the questions or your answers:			

Miscellaneous (Diverse)

These are activities that do not fit in any of the previous categories

Suggested items to consider:	Publications (flyers)		
	Special Events		
	Additional Taxes		
	Unforeseen Costs		
Total Miscellaneous Costs		DKK	
Comments on the questions or your answers:			

WEEE Specific Costs (WEEE Specifikke Omkostninger)

These are activities that only regard WEEE and are not shared by other waste streams

Suggested items to consider:	Educational Events		
	Special Collection Events		
	WEEE Specific Employee Training		
	Miscellaneous		
Total WEEE Specific Costs		DKK	
Comments on the questions or your answers:			

Subtotal WEEE Specific Cost	**--**
Total WEEE Collection Cost	**--**
Comments on the sheet as a whole:	

Figure 15. WEEE Specific Costs

4.5 Stakeholder Interviews

In addition to our discussions with municipal companies, we interviewed major stakeholders in the area of WEEE management to gain further insight on some of the problems with the Danish waste management system and their thoughts on extended producer responsibility in general.

4.5.1 Feedback from Producer Schemes

We talked informally with a representative from one of the Danish producer schemes, the organizations that are hired by producers and importers to handle the treatment of WEEE. For matters of confidentiality, we will keep their affiliation and position within the producer scheme undisclosed. We talked about whether our model would seem fair to the electronics' producers if they were required to pay for WEEE collection. The representative did not find any problems with our cost calculating model as it is. The representative made some suggestions for how a model like ours could be implemented if Danish legislation were to change and producers would have to pay for WEEE collection.

The representative stressed that the model and administrative tasks necessary to collect data should be as simple as possible. He thought that producers would probably prefer to only send out a survey to collect data once or once every five years as opposed to collecting data annually. This is because it would be too much work to collect all the data our survey needs on a regular basis. Municipalities would be paid based on the estimations from previous years and would know how much the producers are going to pay them ahead of time. We were also told that having a simpler model would ensure that the survey we send out would receive more accurate and representative responses, since people would understand it better and have more time to spend on each question. Most of what we learned in this interview was used to develop the Recommendations chapter of this paper.

4.5.2 Feedback from Danish Ministry on the Environment

We also had an informal talk with a representative from the Danish Ministry on the Environmental and learned more about the current and predicted future legislation of EPR in the WEEE system in Denmark. We discussed how the Danish interpreted the WEEE EU directive to mean that producers are only responsible of collecting WEEE from the container stations. She predicted that if change were to occur regarding legislation, it would not be for another year or so because of the EPA's strategy on approaching Parliament (Folketing).

Another topic of conversation was how our model could be used in a political and legal setting. As Folketing currently stands, the top three parties, the Liberals, the Social Democrats, and the Danish People's Party, would be in favor of increasing EPR on WEEE. Our model and the initial numbers we calculate could be used to prepare a case for this expansion of EPR.

We briefly touched upon the subject of the allocation factor. When we asked which factor would be most important when calculating the portion of waste costs specific to WEEE, unlike the other stakeholders involved, she mentioned the surface area used in the container station for WEEE specific activities, like collection and storage. She warned us that if weight and volume would be used, they would be heavily attacked by the producers because the municipalities are not treating the waste and therefore don't have such a direct cost involving either of those two factors as producers. Producers usually pay per ton or container to transport and treat the waste. Because municipalities are just collecting the waste, producers would feel it would be unfair to also charge them by weight and volume.

Lastly we talked about how this model could be implemented and what major problems could arise. She shared the same concerns as the representative from the producer scheme that collecting this data every year would be very taxing on the administration department. She also mentioned the possibility of setting up an incentive for municipalities to collect more WEEE. These two subjects are explained more in depth in the recommendations chapter of this paper.

4.6 Estimate of WEEE

The final step in our project was to take the costs obtained through our spreadsheets and come up with figures for the cost of WEEE collection for the five intermunicipal companies.

We calculated the WEEE collection costs per intermunicipal waste company using the allocation factor determined in the same spreadsheet. The WEEE collection cost was calculated by multiplying the sum of all the costs except the "WEEE Specific Costs", which were added directly to the total (Equation 2). This number was considered the total WEEE collection cost for the intermunicipal companies. These totals can be seen in Table 3. These costs were calculated per ton of WEEE collected and per inhabitant. The spreadsheets used to calculate the costs at each municipal company can be found in Appendix F.

$$WEEE\ Collection\ Cost = (Shared\ Costs * Allocation\ Factor) + WEEE\ Specific\ Costs$$

Equation 2

Table 3. Annual Collection Cost of WEEE at the 5 Intermunicipal Companies Surveyed

Intermunicipal Company	Allocation Factor	Total Cost of Collecting WEEE (DKK)	Cost of Collecting WEEE per ton (DKK/ton)	Cost of Collecting WEEE per Inhabitant (DKK/person)
Odense Renovation A/S	6.47%	3,260,000	1,350	17
Reno Djurs I/S	5.96%	803,000	564	10.1
Forsyning Helsingør A/S	24.70%	1,620,000	2,070	26.6
Horsens Kommune	2.43%	955,000	304	11.7
KARA / NOVEREN	6.89%	4,210,000	1,250	10.4
Average	9.29%	2,169,600	1107.6	16.35

As Table 3 shows, the costs of collecting WEEE can vary a lot between companies. The biggest reason for the disparities between values of collection costs per ton is the time based allocation factor. While the range of values for the weight and volume based allocation factors is relatively small (between 2.03 and 7.40% by weight and between 2.44 and 9.05% by volume), the range of values in the time based allocation factors is huge (from 2.6% in Horsens to 44.6% in Helsingør). This is likely due to the current subjective and inexact nature of determining how much time employees spend on WEEE specific activities because the process of collecting this time data is not as straightforward as collecting data from weight or volume.

Table 4. Summary Table of WEEE Collection Costs in Denmark

Annual cost in Denmark (DKK)	68,200,000
Annual cost per inhabitant in Denmark (DKK/person)	12.4
Average cost per ton of WEEE (DKK/ton)	909

We also estimated the annual cost for Denmark as a whole to be approximately 68.2 million DKK. We obtained this result by dividing the total cost of collecting WEEE for all the places we survey by their number of inhabitants to get the cost per inhabitant (12.4 DKK). We then multiplied that number by the population of Denmark (approx. 5.5 million) to get the cost for all of Denmark. Similarly, we determined the average cost of collecting WEEE per ton by dividing the total cost for everywhere we surveyed by the tons of WEEE collected. We found that the average cost was 909 DKK/ton throughout the country. These values can be seen in Table 4.

Chapter 5: Recommendations and Conclusions

5.1 On Using the Cost Estimation Model

As previously stated, the original goal of this project was to create a cost estimation model for WEEE collection at individual container stations. After developing a model based on a variety of research, we decided to test its effectiveness by sampling a select group of intermunicipal companies. As we pursued this objective, we came to realize that we needed to adapt our objectives to the data that was available. The following paragraphs list more precisely how our model has met the objectives of our study and what further recommendations we have for its use.

One of the advantages of our model is that the spreadsheet used to survey the companies is easy to understand. Originally, we anticipated creating a separate instruction sheet to be attached with the survey sheet when sending it out to the intermunicipal companies. We anticipated this since both the Belgium and Holland models had attached instructions. We brought this subject up when interviewing the intermunicipal companies and most of them (Reno Djurs and Horsens) didn't feel it was necessary. Therefore, instead of focusing on making a separate document, we decided to make the collection sheet as clear and understandable as possible.

A point of debate in our model is the calculation of the allocation factor, the fraction we multiply by the total collection costs to get collection costs for just WEEE. In our interviews we found conflicting views on what factors would most accurately separate WEEE costs from the total costs of collection. The intermunicipal companies suggested it be more heavily based on time spent on dealing with WEEE. The Danish Ministry of the Environment, on the other hand, suggested that space taken up by WEEE containers at the individual container stations be used as the main factor. Further study could be done to determine which factor or combination of factors is best to find the percentage of total costs that are relevant to WEEE. Our model calculated the allocation factor based on weight, volume, and time. From the five companies surveyed, the final weightings of these factors were calculated to be: 20% weight, 35% volume, and 45% time. This is based on our initial feedback from municipal companies; but this can be easily adjusted after further research and discussion. Estimates of time spent on WEEE from the

municipal companies also varied greatly, and since there was no obvious explanation for such large differences we suspect that a time based allocation factor could be too inexact and subjective. We recommend developing a more objective means to calculate the percentage of time spent on WEEE. This could possibly be in the form of more detailed questioning in the spreadsheet or direct observation by independent researchers. Since some municipalities use a punch card system for tracking their employee's work, maybe something could be developed to incorporate WEEE and what time is spent on it.

Another limitation of our project was the fact that few of these companies had numbers for individual container stations but only for the company as a whole. If a company could fill the spreadsheet out for all the individual container stations, it would have required more time to complete. It is still possible to calculate the cost for an individual container station with this model, some of the wording in the questions may need to be altered, but the template would remain the same. One thing to consider is that it is inaccurate to assume all container stations within one intermunicipal company are similar. This was our main deterrent from using our adaptation of Bohr's Equation. If this equation would be used in future works, a method would have to be developed to account for the variability that exists between each container station and in turn every intermunicipal company.

Our model was tested on five companies, from which we calculated the different WEEE collection costs per ton and per inhabitant. Since we used a more detailed model these numbers are probably more accurate than previous estimates which only asked companies to estimate their costs of collecting WEEE. For an even more accurate estimate, we recommend that more intermunicipal companies be surveyed, including companies who are not members of RenoSam, whose costs may be different.

5.2 On the Political Implications of Expanding EPR

Through our interviews with stakeholders involved in this process, including the intermunicipal companies, the producer schemes, the DPA-System, and the Danish Ministry on the Environment, we realized that there are political, administrative, and legal implications to expanding EPR to cover the collection of WEEE at container stations. These were expressed to us as both suggestions and concerns from the parties involved. In this section we present those

concerns as well as suggestions for the future of this system. We believe it is important for the stakeholders to engage in this conversation to discuss further what should be done. This would lead to a more successful and fruitful implementation of our model if legislation was to go through.

The producers' main argument against expanding EPR is that if all the collection costs are covered, municipalities will have no incentive to control their spending or increase their collection amount. Legislation must be set in place to avoid overspending and improve efficiency on the municipalities' part. This could be done by setting upper limits to the costs covered by the producers. If the municipality would exceed that limit, they would have to cover the finances themselves. This limit would be set according to the municipalities' costs for previous years and adjusted based on factors such as inflation. In terms of incentives, there is no current system in place that encourages municipalities to collect more WEEE. It is also likely that if an incentive program were to be created, it would be of an economic nature. This could come in the form of tax exemptions if a certain amount of WEEE is collected or increased bills if a set amount of collection tonnage is not reached.

Another mayor concern for the producers is that they would have to increase the price on their products, and therefore fewer people will buy their products in Denmark. With fewer consumers, producers might be forced to take products out of the market. Denmark is already one of the most expensive countries for producers to sell their goods in because of the high taxation system. The producers are concerned that by adding a new financial responsibility, they will have no choice but to raise their products' cost. While this would encourage consumers to be more mindful about disposing of their electronics, producers would never be for this sort of legislation. To avoid this situation, an agreement could be reached with the municipality on which WEEE related costs would or would not be covered. It is also important to discuss the role the annual municipal waste fees could play in reducing the producer's costs.

A controversial topic contested by the municipalities and the producers is the financial line of where each of their responsibilities start and end. Because of the variety of collection practices in different municipalities (curbside pickup, container station collection, among others) it can be complicated to set a defined limit that can be easily applied to all stations

throughout the country. On the other hand, having the producer schemes set up individual agreements with each of the intermunicipal companies is a very complex logistical operation. The less complicated and fewer exceptions, the clearer the responsibility limits would be. We recommend discussions between both parties and a set of standard responsibilities be created with capped financial limits.

Another concern expressed by all the parties involved is the yearly change of which container stations producer schemes are responsible for. Container stations sometimes have to deal with different people picking up WEEE to be treated every year. We found that this yearly change is taxing on all the parties involved: the producer schemes, the intermunicipal companies, and the DPA-system that organizes the whole logistics. Adding another factor in the calculation of the yearly producer scheme distribution throughout the different companies was not necessarily welcomed by any of the parties involved. In fact, none of them seemed to be very enthusiastic about the current system in place. The municipalities don't like having to adjust to different companies every year, the producer schemes don't like adjusting to the municipalities' idiosyncrasies every year, and the DPA-System doesn't like being stuck between both of these unhappy parties. If EPR was to be expanded, we recommend that it be as convenient as possible for everyone involved. Even if expanding EPR legislation were not to go through, it would be important to have an open discussion about the possibility of changing this system as a whole. Perhaps this problem could be solved by not requiring the producer schemes to change so frequently but rather once every set number of years.

5.3 Conclusions

In summary, we urge the parties involved to have an open discussion about how they would like producer responsibility for WEEE to evolve in Denmark. This project has started new kinds of conversations about producer financial responsibility and WEEE and waste in general. With a cost calculation tool such as the model we developed, the discussion can deal with concrete examples rather than philosophical disagreements. The principal stakeholders in this process must work together to improve the system currently in place by learning from the EU WEEE and Battery Directives and their shortcomings, from other countries and their cost models for WEEE, and from the thoughts each party may bring to the table.

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Appendix A: Municipality Data taken from (DPA System, 2011b)

Municipality	Inhabitants	Inhab./ Collection site	Collection sites	Total WEEE	Total WEEE/Site	Category
Aabenraa	59.765	9.961	6	773.6	128.93	1
Ærø	6.658	6.658	1	174.6	174.60	1
Assens	41.631	5.947	7	732.5	104.64	1
Billund	26.234	8.745	3	423.3	141.10	1
Bornholms Reg.	41.725	6.937	6	512.9	85.48	1
Brøndby	33.968	11.323	3	438.5	146.17	1
Brønderslev	35.784	5.964	6	0	0.00	1
Dragør	13.743	13.743	1	181.2	181.20	1
Egedal	41.69	13.897	3	428.3	142.77	1
Faaborg-Midtfyn	51.691	6.461	8	988.4	123.55	1
Fanø	3.21	3.21	1	106.8	106.80	1
Favrskov	46.922	9.384	5	681.3	136.26	1
Faxe	35.259	11.753	3	599	199.67	1
Fredericia	50.139	10.028	5	805.5	161.10	1
Frederikshavn	61.532	7.692	8	1183.5	147.94	1
Furesø	38.269	19.135	2	346.1	173.05	1
Guldborgsund	62.296	6.922	9	1157.8	128.64	1
Halsnæs	31.06	15.53	2	346.2	173.10	1
Hedensted	46.031	11.508	4	728.9	182.23	1
Herning	85.905	12.272	7	1260.5	180.07	1
Hjørring	66.444	6.04	11	1789.3	162.66	1
Høje Taastrup	47.864	11.966	4	451.5	112.88	1
Hvidovre	50.222	12.556	4	498.4	124.60	1
Ikast-Brande	40.609	10.152	4	617.8	154.45	1
Jammerbugt	38.726	9.682	4	650.6	162.65	1
Kalundborg	49.05	7.007	7	991	141.57	1
Kerteminde	23.708	7.903	3	350.1	116.70	1
Køge	57.215	3.814	15	942.6	62.84	1
Læsø	1.939	1.939	1	29.4	29.40	1
Langeland	13.243	4.414	3	287	95.67	1
Lemvig	21.545	10.773	2	357.3	178.65	1
Lolland	45.986	4.181	11	900	81.82	1
Mariagerfjord	42.57	6.081	7	1141.2	163.03	1
Middelfart	37.692	9.423	4	562.5	140.63	1
Morsø	21.519	10.76	2	258.9	129.45	1
Norddjurs	37.939	7.588	5	717.2	143.44	1
Nordfyns	29.437	9.812	3	553.9	184.63	1
Nyborg	31.581	10.527	3	493.4	164.47	1
Odder	21.838	10.919	2	324	162.00	1
Rebild	28.958	9.653	3	271.2	90.40	1
Ringkøbing-Skj.	58.081	6.453	9	955.1	106.12	1
Samsø	3.866	3.866	1	68	68.00	1
Skanderborg	57.79	11.558	5	804.7	160.94	1
Sønderborg	76.259	8.473	9	744.1	82.68	1
Sorø	29.437	9.812	3	546.4	182.13	1
Stevns	21.874	10.937	2	356	178.00	1
Struer	22.254	11.127	2	345.7	172.85	1
Syddjurs	41.768	4.641	9	921.4	102.38	1
Thisted	45.103	9.021	5	700.2	140.04	1
Tønder	39.446	5.635	7	544.5	77.79	1
Varde	50.355	7.194	7	917	131.00	1

Vejen	42.806	8.561	5	637.9	127.58	1
Vesthimmerlands	37.775	9.444	4	675.4	168.85	1
Viborg	93.65	11.706	8	1276.6	159.58	1
Albertslund	27.799	27.799	1	47.5	47.50	2
Gribskov	40.616	20.308	2	341.4	170.70	2
Hørsholm	24.392	24.392	1	86.2	86.20	2
Ishøj	20.978	20.978	1	114	114.00	2
Solrød	21.003	21.003	1	43.8	43.80	2
Esbjerg	115.169	19.195	6	1401.4	233.57	4
Fredensborg	39.424	13.141	3	673.6	224.53	4
Haderslev	56.122	14.031	4	920	230.00	4
Holbæk	69.548	13.91	5	1232.3	246.46	4
Holstebro	57.213	14.303	4	962.5	240.63	4
Kolding	89.185	17.837	5	1168.3	233.66	4
Næstved	80.856	16.171	5	1323.6	264.72	4
Odsherred	32.795	8.199	4	821	205.25	4
Randers	95.402	19.08	5	1112.5	222.50	4
Rødovre	36.569	18.285	2	708.9	354.45	4
RosSource	82.625	13.771	6	1270.8	211.80	4
Slagelse	77.455	12.909	6	1453.6	242.27	4
Svendborg	58.733	19.578	3	871.7	290.57	4
Tårnby	40.935	13.645	3	790.2	263.40	4
Vordingborg	46.11	11.528	4	970.5	242.63	4
Allerød	24.064	24.064	1	239.8	239.80	5
Århus	311.235	38.904	8	2510.5	313.81	5
Ballerup	47.951	47.951	1	300.7	300.70	5
Glostrup	21.448	21.448	1	386.2	386.20	5
Herlev	26.595	26.595	1	230.5	230.50	5
Hillerød	47.986	47.986	1	334.2	334.20	5
Horsens	83.077	20.769	4	1271.1	317.78	5
Lyngby-Taarbæk	52.883	26.442	2	733.7	366.85	5
Odense	190.448	21.161	9	2160.4	240.04	5
Rudersdal	54.614	27.307	2	575.3	287.65	5
Silkeborg	89.05	22.263	4	1195.7	298.93	5
Skive	47.94	23.97	2	742.1	371.05	5
Vejle	107.346	26.837	4	1599.8	399.95	5
København	541.559	90.26	6	1686.7	281.12	6
Frederikssund	44.256	11.064	4	1822	455.50	7
Greve	47.932	47.932	1	797.8	797.80	8
Lejre	26.75	26.75	1	406.8	406.80	8
Ringsted	32.88	32.88	1	615.9	615.90	8
Aalborg	199.437	99.719	2	2551	1275.50	9
Gladsaxe	65.038	65.038	1	490.2	490.20	9
Helsingør	61.287	61.287	1	833.1	833.10	9
Total	**5.564.219**		**392**	450.1		

Appendix B: RenoSam Member Organizations. Taken From (RenoSam)

Member Organization	Municipality
AffaldPlus	Faxe, Næstved, Ringsted, Slagelse, Sorø and Vordingborg
Albertslund Kommune	Albertslund
Arwos	Trondhjemsvej
AVV	Mandovej
AVOE	Frederishavn
BOFA	Bornholms
ESO 90 I/S	Ringkobing-Skjern and Varde
Favrskov-Forsyning	Favrskov
Feltengard	Favrskov, Skanderborg and Silkeborg
Forsyning	Helsingor
Fredericia	Fredericia
Greve Forsyning	Greve Forsyning
Horsens	Horsens
Ebsjerg Modtagestation	Esbjerg, Fanø, Vejen and Billund
I/S Fælles Forbrænding	Mariager, Randers and Rebild
Nordforbrænding	Allerød, Fredensborg, Helsingør, Hørsholm, Rudersdal
I/S Refa	Guldborgsund, Lolland
IRF	33 færøske
KARA / NOVEREN	Greve, Holbæk, Kalundborg, Køge, Lejre, Odsherred, Roskilde, Solrød and Stevns
Klintholm I/S	Faaborg-Midtfyn, Kerteminde, Langeland, Nyborg, Svendborg and Ærø
L90	Billund, Esbjerg, Fanø, Herning, Hedensted, Holstebro, Ikast-Brande, Lemvig, Ringkøbing-Skjern, Silkeborg, Varde, Vejle, Viborg
Modtagestation Vendsyssel I/S	Brønderslev, Frederikshavn, Hjørring and Læsø
Motas	Middelfart, Assens, Faaborg-Midtfyn, Svendborg, Ærø, Langeland, Odense, Nordfyn, Nyborg, Kerteminde, Aabenraa, Kolding, Fredericia, Hedensted and Horsens
NVRaffald i/s	Holstebro, Lemvig and Struer
Odense Renovation A/S	Odense
Reno Djurs I/S	Norddjurs Syddjurs
Reno Fyn I/S	Nyborg, Kerteminde
Renosyd I/S	Odder and Skanderborg
Renovest I/S	Jammerbugt, Rebild, Vesthimmerland and Aalborg
Revas	Viborg
Ringkøbing-Skjern Kommune	Ringkøbing-Skjern

Silkeborg Genbrug and Affald A/S	Silkeborg
Skive Renovation 4-S	Skive
Svendborg Kraftvarme A/S	Svendborg, Langeland, Ærø, Faaborg-Midtfyn and Nyborg
Svendborg Vand and Affald A/S	Svendborg, Langeland and Ærø
Sydjysk Affaldsvarme I/S	Affaldsregion Nord I/S, Tønder
Sønderborg Affald	Sønderborg
TAS I/S	Fredericia, Kolding, Middelfart, Vejle
Torshavn Forbrændingsanlæg	Torshavn
Tønder Forsyning A/S	Tønder
Varde Forsyning A/S	Varde
Vejen Kommune	Vejen

Appendix C: Sampling Method

To create these 9 categories, we began by manipulating the data seen in Appendix A to include the total WEEE collected per station and the total inhabitants per station for all Danish municipalities that have container stations. Then we used the filtering and sorting function on excel to arrange the data first by population and then by tonnage to see the range of values for each criteria. We put the data into scatter plots (Figure 16) and chose the intervals for our sampling criteria based on the distribution of these values.

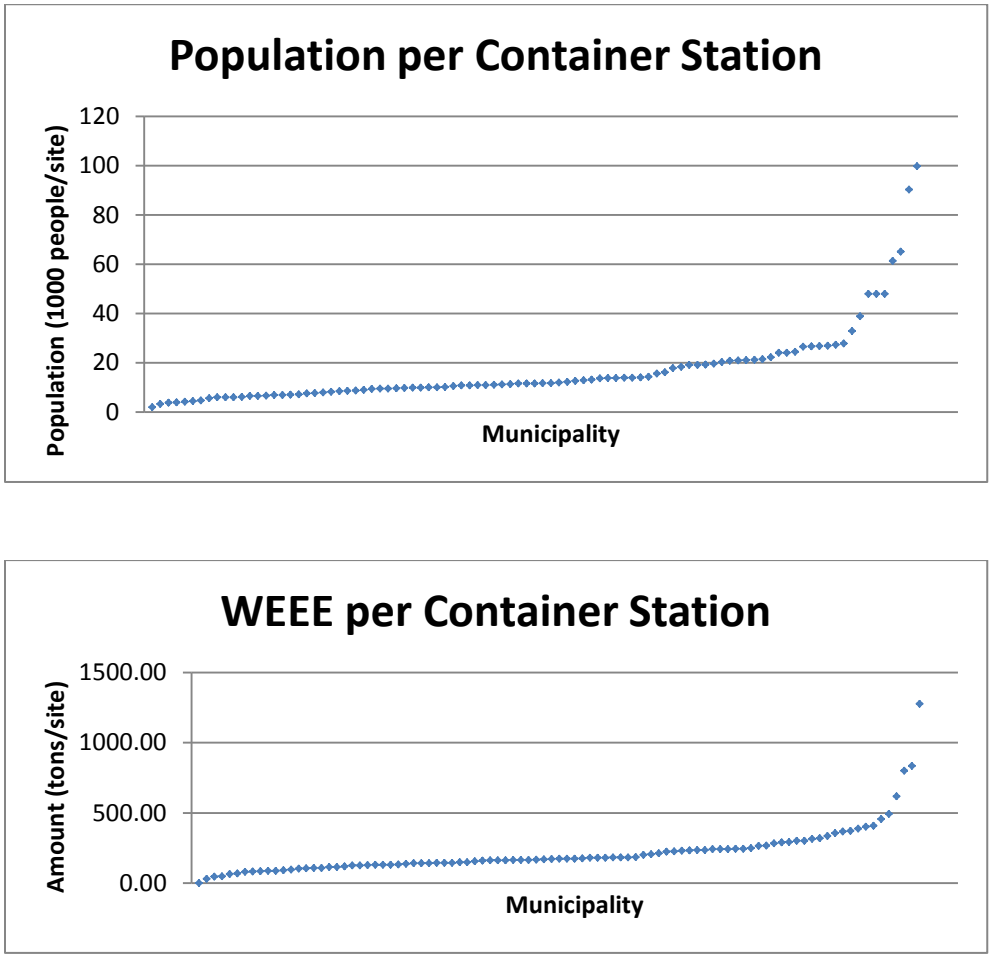

Figure 16. Population and WEEE Per Site. Data taken from DPA, 2010.

A numbering system of 1 through 9 has been assigned to each different possibility. This was achieved using a series of "If" formulas in excel and can be seen in Appendix A.

Appendix D: RenoSam Municipality Categorization.

Name	Category
Faxe	1
Næstved	4
Ringsted	8
Slagelse	4
Sorø	1
Vordingborg	4
Albertslund	2
Frederishavn	1
Bornholms	1
Ringkobing-Skjern	1
Silkeborg	5
Helsingør	9
Fredericia	1
Greve	8
Horsens	5
Esbjerg	4
Fanø	1
Vejen	1
Billund	1
Mariager	1
Randers	4
Rebild	1
Allerød	5
Fredensborg	4
Hørsholm	2
Rudersdal	5
Guldborgsund	1
Lolland	1
Holbæk	4
Kalundborg	1
Køge	1
Lejre	8
Odsherred	4
Solrød	2

Faaborg-Midtfyn	1
Kerterminde	1
Langeland	1
Nyborg	1
Svendborg	4
Herning	1
Hedensted	1
Holstebro	4
Ikast-Brande	1
Lemvig	1
Varde	1
Vejle	5
Viborg	1
Brønderslev	1
Frederikshavn	1
Hjørring	1
Læsø	1
Middlefart	1
Assens	1
Odense	5
Nordfyn	1
Aabenraa	1
Kolding	4
Struer	1
Norddjurs	1
Syddjurs	1
Odder	1
Jammerbugt	1
Vesthimmerland	1
Aalborg	9
Skive	5
Tønder	1
Sønderborg	1
Vejen	1

Appendix E: Revised Model Version 1

This is the model that was developed after examining the Holland and Belgium models. It would later be revised by simplifying the questions to ask for the general costs. There are three sheets, one was to be sent out to companies as a survey, one was to calculate investment costs, and one was to calculate operational costs.

Survey to Calculate Fixed Collection Costs for WEEE

General Information

Residents	*People that are regsitered to use the container station*	*Number*	
Visitors	*Residents that visit the collection station*	*Number*	
Hours Open	*Hours the collection station is open*	*Hours*	

Staffing Costs

Job 1

Employees		*#*	
Working hours per week		*hrs/week*	
Weeks per year		*weeks*	
Labor Cost per hour		*DKK/hr*	

Job 2

Employees		*#*	
Working hours per week		*hrs/week*	
Weeks per year		*weeks*	
Labor Cost per hour		*DKK/hr*	

Job 3

Employees		*#*	
Working hours per week		*hrs/week*	
Weeks per year		*weeks*	
Labor Cost per hour		*DKK/hr*	

Land and Building Areas

Total land area	*Including buildings, collection points, etc.*	*m2*	
Green Areas		*m2*	
Signs and Road Markings		*unit*	
Paved and Impervious Areas		*m2*	
Oil/Grease Separator		*unit*	
Office Area		*m2*	
Gates		*unit*	
Permanent Buildings	*Concrete structures, etc.*	*m2*	
Borders		*m2*	
Reception Area		*m2*	
Hazardous Waste Area	*Deposit area*	*m2*	

Equipment Costs

Wiring and Barriers		*unit*	
Scale		*unit*	
Shredders		*unit*	
Forklift		*unit*	
CCTV and Security System		*unit*	
Fire Protection System	*Fire Extinguishers, sprinklers*	*unit*	
Vehicle Rentals	*annual costs of renting forklifts, shovels, etc.*	*DKK*	
Lighting		*unit*	

Operational Infastructure Costs

Annual rent for building	*rent, mortgage, lease*	*DKK*	
Annual cost handling equipment	*Forklift…*	*DKK*	
Annual cost infrastructure	*Fences, locks…*	*DKK*	
Maintenance Costs	*Paving, cleaning, fixing*	*DKK*	
Inspection, Insurance Costs	*Testing and inspections*	*DKK*	
Electricity	*Annual usage*	*kWh*	
Gas	*Annual usage*	*Nm^3*	
Diesel	*Annual usage*	*liter*	
Water	*Annual usage*	*m^3*	
Telephone	*Annual bill*	*DKK*	

WEEE Specific Infastructure Costs

Amount of containers for WEEE	*Number*	*units*	
Depreciation period	*How often replace*	*years*	
Cost per container		*DKK/unit*	

WEEE Allocation Factor

Amount of WEEE collected		*kg*	
Total amount of waste collected		*kg*	

Investment Costs

Construction

	Unit	Quantity	Price	Total
Preconditioning of the site	*m2*	0	15	0
Pavement	*m2*	0	510	0
Drainage systems (drains, gullies…)	*m2*		40	0
Oil/grease separator	*unit*	0	186000	0
Landscaping	*m2*	0	80	0
Fencing	*m*		260	0
Gates (Sliding…)	*unit*	0	19300	0
Signage and Road Markings	*unit*	0	1500	0
Semi-permanent service building (trailer)	*unit*	0	260000	0
Permanent service building	*m2*	0	750	0
office	*m2*	0	37200	0
Hazardous Waste deposit area	*m2*	0	740000	0
Additional Field Equipment				0
Additional Site Facilities				0
Total Construction Costs				0

Mechanical and Electrical

Barriers, including wiring	*unit*	0	37200	0
Scales	*unit*	0	186000	0
Security system	*unit*	0	18600	0
lighting, including wiring	*unit*	0	11200	0
Fire protection system	*unit*	0	3000	0
telephone and data connections set up	*unit*		7400	0
HVAC - heating and vent system	*unit*		15000	0
Water connections			11200	0
Additional Mechanical or Electrical equipment				0
Additional Mechanical or Electrical Facilities				0
Total Mechanical and Electrical Costs				0

Vehicles

Shredder	*unit*	0		0
Forklift	*unit*	0		0
Additional vehicles/equipment	*unit*			0
Total Vehicle and Equipment Costs				0

Indirect Costs

One time, construction site, and implementation costs	%	10%	0	0

Total Construction Costs	0

Real Estate

Land acquisition	m2	0	1200	0
Indirect costs (notary, transfer tax, bank charges)	%	10%	0	0
Accidental property	%	0%	0	0

Total Realty Costs	0

Engineering, Preparation, Administration, Supervision

Project	%	2%	0	0
Engineering/Designing Costs	%	8%	0	0
Supervising Construction	%	2%	0	0
Studies and Research	%	2%	0	0
Further detailing	%	0%	0	0

Total Engineering and Preparation Costs	0

Other Costs

Fees, licenses	%	0.50%	0	0
Insurance during construction	%	0.50%	0	0
Other unforeseen	%	10%	0	0

Total Other Costs	0

Summary

Construction	#DIV/0!	0
Property	#DIV/0!	0
Engineering, Preparation, Supervision	#DIV/0!	0
Other	#DIV/0!	0

VAT

VAT on all costs except real estate	%	19%	0	0

Total Investment Costs	0

Appendix F: Municipal Company Calculations

Helsingor

Survey to Calculate Past Year's Collection Costs for WEEE

The goal of this survey is to collect the total costs of handling waste at all container stations in your intermunicipal waste company. This information will be used to estimate the cost of collecting WEEE and to lobby for legislation that would require producers to take financial responsibility for the collection costs.
Please enter totals for all your container stations in the orange. Base the numbers out of the most recent and complete budget you have available.

Questions or comments may be directed to Niels Remtoft of RenoSam at Phone: 46 74 01 13 or nir@renosam.dk

General Information

Number of Container Stations in Company?	Number	1
How many residents in total are regsitered to use the container stations under your management?	Number	61000
How many residents in total visit the collection stations each year?	Number	250000
How many hours per week are all the container stations in your company in operation?	Hours	
Comments on the questions or your answers?		

WEEE Allocation Factor (WEEE Tildeling Faktor)

Please report how many tons of waste you collect in each waste stream you collect:		Amount Collected	Density (tons/m3)	Volume
WEEE	Tons	783	0.2	3915
Accumulators (Car Batteries)	Tons	21	0.8	26.25
Asbestos	Tons		0.3	0
Concrete and Brick	Tons	4.4	1	4.4
Landfill	Tons	2,607	1	2607
Tires	Tons	46	0.1	460
Commercial Recycling	Tons	0	0.2	0
Hazardous Waste	Tons	168	0.05	3360
Bottles and Glass	Tons	215	1	215
Gypsum	Tons	325	0.5	650
Glass with Frames	Tons		1	0
Garden Waste	Tons	6,363	0.2	31815
Hard Plastic	Tons	3.9	0.2	19.5
Rigid PVC	Tons	40	0.2	200
Impregnated wood	Tons		0.25	0
Iron and Metal	Tons		0.5	0
Cable and wires	Tons		0.2	0
Clinical Risk Waste	Tons		0.05	0
Paper and Cardboard	Tons		0.05	0
Plastic "cling" wrap	Tons		0.05	0
Clean soil	Tons		0.2	0
Combustible	Tons		0.2	0
Gas Cylinders	Tons		0.2	0

Clothing and shoes	Tons		0.05	0
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Totals		**10576.3**		**43272**

Weight Allocation	**0.074033452**
Volume Allocation	**0.090473896**

Comments on the questions or your answers:	24.930 total amount look for more information in the Annual report

How many total hours are all your container stations open a week?		Hours	56
How many total hours do you spend on WEEE a week for all your container stations?	*Including:* *Guiding people to WEEE containers* *Cleaning WEEE* *Handling WEEE containers* *Operators talking about collecting WEEE*	Hours	25
What percentage of time would you estimate employees spend on activities relating to WEEE?		%	0.446428571
Comments on the questions or your answers:	1/2 man pr. day		

Time Allocation	**0.446428571**

Weighted Averages (Wighted Gennemsnit)

We are considering several methods to calculate the percentage of total costs that WEEE is responsible for. Please tell us how important you think various methods are (for example: very important, somewhat important, not important at all)

The factors include:
(weight of WEEE collected) divided by (weight of all waste collected)
(volume of WEEE collected) divided by (volume of all waste collected)
(staff time spent on WEEE) divided by (total staff time)

		Percent
How important is weight?	less	**20%**
How important is volume?	more	**35%**
How important is the time dedicated to WEEE at the stations?	important	**45%**
Comments on the questions or your answers:		**100%**

Overall WEEE Allocation Factor	**24.74%**

Staffing Costs (Personaleudgifter)

The costs associated with staffing the collection stations throughout the year

Suggested items to consider:
Salaries
Training/Education

Clothing
Overtime Extra
Additional Monetary Benefits
Consultants
Pensions
Miscellaneous

Total Staffing Costs	DKK	3,141,000
Comments on the questions or your answers:		

Real Estate Costs (Ejendomsmæglere Omkostninger)

The annual amount you pay on rent or mortage on the collection station facilities

Real Estate rent/mortgage	DKK	400,000
Comments on the questions or your answers:		

Maintenance

The annual cost of maintaining the collection station facilities

Suggested items to consider:

Landscaping Green Areas
Paved and Impervious Areas
Fencing
Gates
Signs and Road Markings

New construction of Permanent Buildings
Oil/Grease Separator
Maintaining Hazardous Waste Area
Maintaining Reception/Office Area
Cleaning
Miscellaneous

Total Maintenance Costs	DKK	330,000
Comments on the questions or your answers:		

Equipment Costs (omkostninger til udstyr)

The total costs of purchasing/renting/maintaining equipment necessary for collection waste this past year

Suggested items to consider:

Buying, Renting, and Maintaining
Wiring and Barriers
Equipment Insurance
Containers
Tools
Fixtures
Computers
Cars
Scales
Shredders
Forklift
CCTV and Security System
Miscellaneous

Total Equipment Costs	DKK	1,175,000
Comments on the questions or your answers:		

Utilities

The annual costs of the utilities to run the collection stations facilities

Suggested items to consider:
- Electricity
- Gas
- Diesel
- Water
- Heating
- Telephone
- Internet
- Website Domain
- Miscellaneous

Total Utilities Costs	DKK	
Comments on the questions or your answers:		

Total Waste Shared Costs	**5056000**
Subtotal WEEE Costs (with Allocation Factor)	**1250679.519**

Bulky Waste Collection Costs (Storskraldsordninger)

If you collect WEEE through curbside collection, please provide the total of the following costs

Suggested items to consider:
- Transportation vehicles
- Gasoline and fuel for the vehicles
- Employee costs
- Logistic and planning costs

Total Bulky Waste Collection Costs	DKK	11,415,000
What percetage of your bulky waste collection do you estimate is WEEE?	%	2.80%
Comments on the questions or your answers:		

Miscellaneous (Diverse)

These are activities that do not fit in any of the previous categories

Suggested items to consider:
- Publications (flyers)
- Special Events
- Additional Taxes
- Unforeseen Costs

Total Miscellaneous Costs	DKK	10,000
Comments on the questions or your answers:		

WEEE Specific Costs (WEEE Specifikke Omkostninger)

These are activities that only regard WEEE and are not shared by other waste streams

Suggested items to consider:
- Educational Events
- Special Collection Events
- WEEE Specific Employee Training
- Miscellaneous

Total WEEE Specific Costs	DKK	50,000
Comments on the questions or your answers:		

Subtotal WEEE Specific Cost	369620

Total WEEE Collection Cost	1620299.519

Comments on the sheet as a whole:	

Odense

Survey to Calculate Past Year's Collection Costs for WEEE

The goal of this survey is to collect the total costs of handling waste at all container stations in your intermunicipal waste company. This information will be used to estimate the cost of collecting WEEE and to lobby for legislation that would require producers to take financial responsibility for the collection costs.
Please enter totals for all your container stations in the orange. Base the numbers out of the most recent and complete budget you have available.

Questions or comments may be directed to Niels Remtoft of RenoSam at Phone: 46 74 01 13 or nir@renosam.dk

General Information

Number of Container Stations in Company?	Number	8
How many residents in total are regsitered to use the container stations under your management?	Number	191610
How many residents in total visit the collection stations each year?	Number	188000
How many hours per week are all the container stations in your company in operation?	Hours	464
Comments on the questions or your answers?		

WEEE Allocation Factor (WEEE Tildeling Faktor)

Please report how many tons of waste you collect in each waste stream you collect:		Amount Collected	Density (tons/m3)	Volume
WEEE	Tons	2420	0.2	12100
Accumulators (Car Batteries)	Tons	29	0.8	36.25
Asbestos	Tons	992	0.3	3306.666667
Concrete and Brick	Tons	16700	1	16700
Landfill	Tons	3040	1	3040
Tires	Tons	101	0.1	1010
Commercial Recycling	Tons		0.2	0
Hazardous Waste	Tons	350	0.05	7000
Bottles and Glass	Tons	2636	1	2636
Gypsum	Tons	899	0.5	1798
Glass with Frames	Tons	1050	1	1050
Garden Waste	Tons	23600	0.2	118000
Hard Plastic	Tons	732	0.2	3660
Rigid PVC	Tons	500	0.2	2500
Impregnated wood	Tons	760	0.25	3040
Iron and Metal	Tons	3600	0.5	7200
Cable and wires	Tons	28	0.2	140

Clinical Risk Waste	Tons	14	0.05	280
Paper and Cardboard	Tons	3000	0.05	60000
Plastic "cling" wrap	Tons	0	0.05	0
Clean soil	Tons	10800	0.2	54000
Combustible	Tons	16665	0.2	83325
Gas Cylinders	Tons	3	0.2	15
Clothing and shoes	Tons	480	0.05	9600
gulvtæpper	Tons	518	0.2	
cd-dvd video	Tons	44	0.2	
batteri til veeee	Tons	18	0.2	
Additional Waste Streams?	Tons		0.2	
Additional Waste Streams?	Tons		0.2	
Totals		**88979**		**390436.9167**

Weight Allocation	**0.027197429**
Volume Allocation	**0.030990922**

Comments on the questions or your answers:	men også husstands for paper

How many total hours are all your container stations open a week?		Hours	464
How many total hours do you spend on WEEE a week for all your container stations?	*Including:* *Guiding people to WEEE containers* *Cleaning WEEE* *Handling WEEE containers* *Operators talking about collecting WEEE*	Hours	50
What percentage of time would you estimate employees spend on activities relating to WEEE?		%	0.107758621
Comments on the questions or your answers:			

Time Allocation	**0.107758621**

Weighted Averages (Wighted Gennemsnit)

We are considering several methods to calculate the percentage of total costs that WEEE is responsible for. Please tell us how important you think various methods are (for example: very important, somewhat important, not important at all)

The factors include: (weight of WEEE collected) divided by (weight of all waste collected)
(volume of WEEE collected) divided by (volume of all waste collected)
(staff time spent on WEEE) divided by (total staff time)

		Percent
How important is weight?		**20%**
How important is volume?		**35%**
How important is the time dedicated to WEEE at the stations?		**45%**
Comments on the questions or your answers:		**100%**

Overall WEEE Allocation Factor	**0.064777688**

Staffing Costs (Personaleudgifter)

The costs associated with staffing the collection stations throughout the year

Suggested items to consider:

- Salaries
- Training/Education
- Clothing
- Overtime Extra
- Additional Monetary Benefits
- Consultants
- Pensions
- Miscellaneous

Total Staffing Costs	DKK	22000000
Comments on the questions or your answers:		

Real Estate Costs (Ejendomsmæglere Omkostninger)

The annual amount you pay on rent or mortage on the collection station facilities

Real Estate rent/mortgage	DKK	6300000
Comments on the questions or your answers:		

Maintenance

The annual cost of maintaining the collection station facilities

Suggested items to consider:

- Landscaping Green Areas
- Paved and Impervious Areas
- Fencing
- Gates
- Signs and Road Markings
- New construction of Permanent Buildings
- Oil/Grease Separator
- Maintaining Hazardous Waste Area
- Maintaining Reception/Office Area
- Cleaning
- Miscellaneous

Total Maintenance Costs	DKK	4000000
Comments on the questions or your answers:		

Equipment Costs (omkostninger til udstyr)

The total costs of purchasing/renting/maintaining equipment necessary for collection waste this past year

Suggested items to consider:

- Buying, Renting, and Maintaining
- Wiring and Barriers
- Equipment Insurance
- Containers
- Tools
- Fixtures
- Computers
- Cars
- Scales
- Shredders

Forklift
CCTV and Security System
Miscellaneous

Total Equipment Costs	DKK	5000000
Comments on the questions or your answers:		

Utilities

The annual costs of the utilities to run the collection stations facilities

Suggested items to consider:
Electricity
Gas
Diesel
Water
Heating
Telephone
Internet
Website Domain
Miscellaneous

Total Utilities Costs	DKK	1500000
Comments on the questions or your answers:		

Total Waste Shared Costs	**39500000**
Subtotal WEEE Costs (with Allocation Factor)	**2558718.664**

Bulky Waste Collection Costs (Storskraldsordninger)

If you collect WEEE through curbside collection, please provide the total of the following costs

Suggested items to consider:
Transportation vehicles
Gasoline and fuel for the vehicles
Employee costs
Logistic and planning costs

Total Bulky Waste Collection Costs	DKK	2100000
What percetage of your bulky waste collection do you estimate is WEEE?	%	0.214285714
Comments on the questions or your answers:		

Miscellaneous (Diverse)

These are activities that do not fit in any of the previous categories

Suggested items to consider:
Publications (flyers)
Special Events
Additional Taxes
Unforeseen Costs

Total Miscellaneous Costs	DKK	700000
Comments on the questions or your answers:		

WEEE Specific Costs (WEEE Specifikke Omkostninger)

These are activities that only regard WEEE and are not shared by other waste streams

Suggested items to consider:
Educational Events
Special Collection Events

WEEE Specific Employee Training
Miscellaneous

Total WEEE Specific Costs	DKK	250000
Comments on the questions or your answers:		

Subtotal WEEE Specific Cost	**700000**

Total WEEE Collection Cost	**3258718.664**

Comments on the sheet as a whole:	

Horsens

Survey to Calculate Past Year's Collection Costs for WEEE

The goal of this survey is to collect the total costs of handling waste at all container stations in your intermunicipal waste company. This information will be used to estimate the cost of collecting WEEE and to lobby for legislation that would require producers to take financial responsibility for the collection costs.
Please enter totals for all your container stations in the orange. Base the numbers out of the most recent and complete budget you have available.

Questions or comments may be directed to Niels Remtoft of RenoSam at Phone: 46 74 01 13 or nir@renosam.dk

General Information

Number of Container Stations in Company?	Number	4
How many residents in total are regsitered to use the container stations under your management?	Number	20489
How many residents in total visit the collection stations each year?	Number	400000
How many hours per week are all the container stations in your company in operation?	Hours	66.5
Comments on the questions or your answers?	Numbers were given for 1 container station (Horsens genbrugsplads), so residents register is actually population/4	

WEEE Allocation Factor (WEEE Tildeling Faktor)

Please report how many tons of waste you collect in each waste stream you collect:		Amount Collected	Density (tons/m3)	Volume
WEEE	Tons	785	0.2	3925
Accumulators (Car Batteries)	Tons	32	0.8	40
Asbestos	Tons	1349	0.3	4496.67
Concrete and Brick	Tons	8669	1	8669
Landfill	Tons	1567	1	1567
Tires	Tons	146	0.1	1460
Commercial Recycling	Tons	0	0.2	0
Hazardous Waste	Tons	200	0.05	4000
Bottles and Glass	Tons	348	1	348
Gypsum	Tons	549	0.5	1098
Glass with Frames	Tons	286	1	286

Garden Waste	Tons	8,000	0.2	40000
Hard Plastic	Tons	27	0.2	135
Rigid PVC	Tons	46	0.2	230
Impregnated wood	Tons	1395	0.25	5580
Iron and Metal	Tons	1334	0.5	2668
Cable and wires	Tons	10	0.2	50
Clinical Risk Waste	Tons	0	0.05	0
Paper and Cardboard	Tons	971	0.05	19420
Plastic "cling" wrap	Tons	24	0.05	480
Clean soil	Tons	4909	0.2	24545
Combustible	Tons	5181	0.2	25905
Gas Cylinders	Tons	5	0.2	25
Clothing and shoes	Tons	80	0.05	1600
wood	Tons	2804	0.2	14020
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Totals		**38717**		**160548**

Weight Allocation	**0.020275331**
Volume Allocation	**0.024447568**

Comments on the questions or your answers:	mængder indsamlet på Horsens genbrugsplads 2011 (* = mængden er skønnet)

How many total hours are all your container stations open a week?		Hours	66.5
How many total hours do you spend on WEEE a week for all your container stations?	*Including:* *Guiding people to WEEE containers* *Cleaning WEEE* *Handling WEEE containers* *Operators talking about collecting WEEE*	Hours	10
What percentage of time would you estimate employees spend on activities relating to WEEE?		%	2.60%
Comments on the questions or your answers:	(Horsens genbrugsplads bruger 390 mandetimer pr uge, heraf ca 10 timer pr uge til weee =2,6 %		

Time Allocation	**0.026**

Weighted Averages (Wighted Gennemsnit)

We are considering several methods to calculate the percentage of total costs that WEEE is responsible for. Please tell us how important you think various methods are (for example: very important, somewhat important, not important at all)

The factors include:

(weight of WEEE collected) divided by (weight of all waste collected)

(volume of WEEE collected) divided by (volume of all waste collected)

(staff time spent on WEEE) divided by (total staff time)

		Percent
How important is weight?	10	20%
How important is volume?	40	35%

How important is the time dedicated to WEEE at the stations?	50	45%
Comments on the questions or your answers:	Vores omkostninger til håndtering af weee relaterer sig til volumen (enheder/bure/containere) idet det tager en vis tid pr. bur der skal flyttes / opsilles. Vi har ikke en opgørelse på det samlede volumen af alt affald. Alle vore øvrige affaldstyper vejes og opgøres i ton.	100%

Overall WEEE Allocation Factor	**0.024311715**

Staffing Costs (Personaleudgifter)

The costs associated with staffing the collection stations throughout the year

Suggested items to consider:

- Salaries
- Training/Education
- Clothing
- Overtime Extra
- Additional Monetary Benefits
- Consultants
- Pensions
- Miscellaneous

Total Staffing Costs	DKK	5,638,194
Comments on the questions or your answers:	beløbet svarer til at der i 2011 blev der konteret 20.379 mandetimer på genbrugspladsen i Horsens	

Real Estate Costs (Ejendomsmæglere Omkostninger)

The annual amount you pay on rent or mortage on the collection station facilities

Real Estate rent/mortgage	DKK	0
Comments on the questions or your answers:		

Maintenance

The annual cost of maintaining the collection station facilities

Suggested items to consider:

- Landscaping Green Areas
- Paved and Impervious Areas
- Fencing
- Gates
- Signs and Road Markings

- New construction of Permanent Buildings
- Oil/Grease Separator
- Maintaining Hazardous Waste Area
- Maintaining Reception/Office Area
- Cleaning
- Miscellaneous

Total Maintenance Costs	DKK	415,864
Comments on the questions or your answers:		

Equipment Costs (omkostninger til udstyr)

The total costs of purchasing/renting/maintaining equipment necessary for collection waste this past year

Suggested items to consider:

- Buying, Renting, and Maintaining
- Wiring and Barriers

Equipment Insurance
Containers
Tools
Fixtures
Computers
Cars
Scales
Shredders
Forklift
CCTV and Security System
Miscellaneous

Total Equipment Costs	DKK	1,970,850
Comments on the questions or your answers:	Beløbet indeholder væsentligst udgifter til maskinpark - samt lejede containere.	

Utilities

The annual costs of the utilities to run the collection stations facilities

Suggested items to consider:
Electricity
Gas
Diesel
Water
Heating
Telephone
Internet
Website Domain
Miscellaneous

Total Utilities Costs	DKK	298,825
Comments on the questions or your answers:		

Total Waste Shared Costs	**8323733**
Subtotal WEEE Costs (with Allocation Factor)	**202364.2249**

Bulky Waste Collection Costs (Storskraldsordninger)

If you collect WEEE through curbside collection, please provide the total of the following costs

Suggested items to consider:
Transportation vehicles
Gasoline and fuel for the vehicles
Employee costs
Logistic and planning costs

Total Bulky Waste Collection Costs	DKK	242,513
What percetage of your bulky waste collection do you estimate is WEEE?	%	15%
Comments on the questions or your answers:		

Miscellaneous (Diverse)

These are activities that do not fit in any of the previous categories

Suggested items to consider:
Publications (flyers)
Special Events
Additional Taxes
Unforeseen Costs

Total Miscellaneous Costs	DKK	0

Comments on the questions or your answers:	

WEEE Specific Costs (WEEE Specifikke Omkostninger)

These are activities that only regard WEEE and are not shared by other waste streams

Suggested items to consider:
- Educational Events
- Special Collection Events
- WEEE Specific Employee Training
- Miscellaneous

Total WEEE Specific Costs	DKK	0
Comments on the questions or your answers:		

Subtotal WEEE Specific Cost	**36376.95**

Total WEEE Collection Cost	**238741.1749**

Comments on the sheet as a whole:	

KARA/NOVEREN

Survey to Calculate Past Year's Collection Costs for WEEE

The goal of this survey is to collect the total costs of handling waste at all container stations in your intermunicipal waste company. This information will be used to estimate the cost of collecting WEEE and to lobby for legislation that would require producers to take financial responsibility for the collection costs.
Please enter totals for all your container stations in the orange. Base the numbers out of the most recent and complete budget you have available.

Questions or comments may be directed to Niels Remtoft of RenoSam at Phone: 46 74 01 13 or nir@renosam.dk

General Information

Number of Container Stations in Company?	Number	14
How many residents in total are regsitered to use the container stations under your management?	Number	406,131
How many residents in total visit the collection stations each year?	Number	1,250,000
How many hours per week are all the container stations in your company in operation?	Hours	816
Comments on the questions or your answers?		

WEEE Allocation Factor (WEEE Tildeling Faktor)

Please report how many tons of waste you collect in each waste stream you collect:		Amount Collected	Density (tons/m3)	Volume
WEEE	Tons	3382	0.2	16910
Accumulators (Car Batteries)	Tons	120	0.8	150
Asbestos	Tons	2754	0.3	9180

Concrete and Brick	Tons	22868	1	22868
Landfill	Tons	3554	1	3554
Tires	Tons	547	0.1	5470
Commercial Recycling	Tons		0.2	0
Hazardous Waste	Tons	888	0.05	17760
Bottles and Glass	Tons	1561	1	1561
Gypsum	Tons	2076	0.5	4152
Glass with Frames	Tons	1766	1	1766
Garden Waste	Tons	35849	0.2	179245
Hard Plastic	Tons		0.2	0
Rigid PVC	Tons	350	0.2	1750
Impregnated wood	Tons	1820	0.25	7280
Iron and Metal	Tons	6301	0.5	12602
Cable and wires	Tons		0.2	0
Clinical Risk Waste	Tons	75	0.05	1500
Paper and Cardboard	Tons	2945	0.05	58900
Plastic "cling" wrap	Tons	19	0.05	380
Clean soil	Tons	11475	0.2	57375
Combustible	Tons		0.2	0
Gas Cylinders	Tons		0.2	0
Clothing and shoes	Tons		0.05	0
waste to energy use	Tons	38815	0.2	194075
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Totals		**137165**		**596478**

Weight Allocation	**0.024656436**
Volume Allocation	**0.028349746**

Comments on the questions or your answers:	

How many total hours are all your container stations open a week?		Hours	816
How many total hours do you spend on WEEE a week for all your container stations?	*Including:* *Guiding people to WEEE containers* *Cleaning WEEE* *Handling WEEE containers* *Operators talking about collecting WEEE*	Hours	98
What percentage of time would you estimate employees spend on activities relating to WEEE?		%	12.00980392
Comments on the questions or your answers:			

Time Allocation	**12.00980392**

Weighted Averages (Wighted Gennemsnit)

We are considering several methods to calculate the percentage of total costs that WEEE is responsible for. Please tell us how

important you think various methods are (for example: very important, somewhat important, not important at all)

The factors include: (weight of WEEE collected) divided by (weight of all waste collected)
(volume of WEEE collected) divided by (volume of all waste collected)
(staff time spent on WEEE) divided by (total staff time)

		Percent
How important is weight?	non	**20%**
How important is volume?	some	**35%**
How important is the time dedicated to WEEE at the stations?	some	**45%**
Comments on the questions or your answers:		**100%**

Overall WEEE Allocation Factor	**5.419265463**

Staffing Costs (Personaleudgifter)

The costs associated with staffing the collection stations throughout the year

Suggested items to consider:
- Salaries
- Training/Education
- Clothing
- Overtime Extra
- Additional Monetary Benefits
- Consultants
- Pensions
- Miscellaneous

Total Staffing Costs	DKK	19,500,000
Comments on the questions or your answers:		

Real Estate Costs (Ejendomsmæglere Omkostninger)

The annual amount you pay on rent or mortage on the collection station facilities

Real Estate rent/mortgage	DKK	0
Comments on the questions or your answers:		

Maintenance

The annual cost of maintaining the collection station facilities

Suggested items to consider:
- Landscaping Green Areas
- Paved and Impervious Areas
- Fencing
- Gates
- Signs and Road Markings
- New construction of Permanent Buildings
- Oil/Grease Separator
- Maintaining Hazardous Waste Area
- Maintaining Reception/Office Area
- Cleaning
- Miscellaneous

Total Maintenance Costs	DKK	12,000,000

Comments on the questions or your answers:	

Equipment Costs (omkostninger til udstyr)

The total costs of purchasing/renting/maintaining equipment necessary for collection waste this past year

Suggested items to consider:

- Buying, Renting, and Maintaining
- Wiring and Barriers
- Equipment Insurance
- Containers
- Tools
- Fixtures
- Computers
- Cars
- Scales
- Shredders
- Forklift
- CCTV and Security System
- Miscellaneous

Total Equipment Costs	DKK	2,500,000
Comments on the questions or your answers:		

Utilities

The annual costs of the utilities to run the collection stations facilities

Suggested items to consider:

- Electricity
- Gas
- Diesel
- Water
- Heating
- Telephone
- Internet
- Website Domain
- Miscellaneous

Total Utilities Costs	DKK	800,000
Comments on the questions or your answers:		

Total Waste Shared Costs	**35050000**
Subtotal WEEE Costs (with Allocation Factor)	**189945254.5**

Bulky Waste Collection Costs (Storskraldsordninger)

If you collect WEEE through curbside collection, please provide the total of the following costs

Suggested items to consider:

- Transportation vehicles
- Gasoline and fuel for the vehicles
- Employee costs
- Logistic and planning costs

Total Bulky Waste Collection Costs	DKK	12,000,000
What percetage of your bulky waste collection do you estimate is WEEE?	%	0.15
Comments on the questions or your answers:		

Miscellaneous (Diverse)

These are activities that do not fit in any of the previous categories

Suggested items to consider:
- Publications (flyers)
- Special Events
- Additional Taxes
- Unforeseen Costs

Total Miscellaneous Costs	DKK	250,000
Comments on the questions or your answers:		

WEEE Specific Costs (WEEE Specifikke Omkostninger)

These are activities that only regard WEEE and are not shared by other waste streams

Suggested items to consider:
- Educational Events
- Special Collection Events
- WEEE Specific Employee Training
- Miscellaneous

Total WEEE Specific Costs	DKK	0
Comments on the questions or your answers:		

Subtotal WEEE Specific Cost	**1800000**

Total WEEE Collection Cost	**191745254.5**

Comments on the sheet as a whole:	

Reno Djurs

Survey to Calculate Past Year's Collection Costs for WEEE

The goal of this survey is to collect the total costs of handling waste at all container stations in your intermunicipal waste company. This information will be used to estimate the cost of collecting WEEE and to lobby for legislation that would require producers to take financial responsibility for the collection costs.
Please enter totals for all your container stations in the orange. Base the numbers out of the most recent and complete budget you have available.

Questions or comments may be directed to Niels Remtoft of RenoSam at Phone: 46 74 01 13 or nir@renosam.dk

General Information

Number of Container Stations in Company?	Number	9
How many residents in total are regsitered to use the container stations under your management?	Number	79691
How many residents in total visit the collection stations each year?	Number	500376
How many hours per week are all the container stations in your company in operation?	Hours	38
Comments on the questions or your answers?		

WEEE Allocation Factor (WEEE Tildeling Faktor)

Please report how many tons of waste you collect in each waste stream you collect:		Amount Collected	Density (tons/m3)	Volume
WEEE	Tons	1424	0.2	**7120**
Accumulators (Car Batteries)	Tons		0.8	**0**
Asbestos	Tons		0.3	**0**
Concrete and Brick	Tons		1	**0**
Landfill	Tons		1	**0**
Tires	Tons		0.1	**0**
Commercial Recycling	Tons		0.2	**0**
Hazardous Waste	Tons		0.05	**0**
Bottles and Glass	Tons		1	**0**
Gypsum	Tons		0.5	**0**
Glass with Frames	Tons		1	**0**
Garden Waste	Tons		0.2	**0**
Hard Plastic	Tons		0.2	**0**
Rigid PVC	Tons		0.2	**0**
Impregnated wood	Tons		0.25	**0**
Iron and Metal	Tons		0.5	**0**
Cable and wires	Tons		0.2	**0**
Clinical Risk Waste	Tons		0.05	**0**
Paper and Cardboard	Tons		0.05	**0**
Plastic "cling" wrap	Tons		0.05	**0**
Clean soil	Tons		0.2	**0**
Combustible	Tons		0.2	**0**
Gas Cylinders	Tons		0.2	**0**
Clothing and shoes	Tons		0.05	**0**
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Additional Waste Streams?	Tons			
Totals		51622		**258110**

Weight Allocation	**0.027585138**
Volume Allocation	**0.027585138**

Comments on the questions or your answers:	

How many total hours are all your container stations open a week?		Hours	38
How many total hours do you spend on WEEE a week for all your container stations?	*Including:* *Guiding people to WEEE containers* *Cleaning WEEE* *Handling WEEE containers* *Operators talking about collecting WEEE*	Hours	3.75
What percentage of time would you estimate employees spend on activities relating to WEEE?		%	0.098684211
Comments on the questions or your answers:			

Time Allocation	0.098684211

Weighted Averages (Wighted Gennemsnit)

We are considering several methods to calculate the percentage of total costs that WEEE is responsible for. Please tell us how important you think various methods are (for example: very important, somewhat important, not important at all)

The factors include: (weight of WEEE collected) divided by (weight of all waste collected)
(volume of WEEE collected) divided by (volume of all waste collected)
(staff time spent on WEEE) divided by (total staff time)

		Percent
How important is weight?		20%
How important is volume?		35%
How important is the time dedicated to WEEE at the stations?		45%
Comments on the questions or your answers:		100%

Overall WEEE Allocation Factor	0.059579721

Staffing Costs (Personaleudgifter)

The costs associated with staffing the collection stations throughout the year

Suggested items to consider:
Salaries
Training/Education
Clothing
Overtime Extra
Additional Monetary Benefits
Consultants
Pensions
Miscellaneous

Total Staffing Costs	DKK	6770138.45
Comments on the questions or your answers:		

Real Estate Costs (Ejendomsmæglere Omkostninger)

The annual amount you pay on rent or mortage on the collection station facilities

Real Estate rent/mortgage	DKK	297613.68
Comments on the questions or your answers:		

Maintenance

The annual cost of maintaining the collection station facilities

Suggested items to consider:
Landscaping Green Areas
Paved and Impervious Areas
Fencing
Gates
Signs and Road Markings

New construction of Permanent Buildings
Oil/Grease Separator

Maintaining Hazardous Waste Area
Maintaining Reception/Office Area
Cleaning
Miscellaneous

Total Maintenance Costs	DKK	3010112.55
Comments on the questions or your answers:		

Equipment Costs (omkostninger til udstyr)

The total costs of purchasing/renting/maintaining equipment necessary for collection waste this past year

Suggested items to consider:
Buying, Renting, and Maintaining
Wiring and Barriers
Equipment Insurance
Containers
Tools
Fixtures
Computers
Cars
Scales
Shredders
Forklift
CCTV and Security System
Miscellaneous

Total Equipment Costs	DKK	2917849.73
Comments on the questions or your answers:		

Utilities

The annual costs of the utilities to run the collection stations facilities

Suggested items to consider:
Electricity
Gas
Diesel
Water
Heating
Telephone
Internet
Website Domain
Miscellaneous

Total Utilities Costs	DKK	180491.19
Comments on the questions or your answers:		

Total Waste Shared Costs	**13474987.66**
Subtotal WEEE Costs (with Allocation Factor)	**802836.0013**

Bulky Waste Collection Costs (Storskraldsordninger)

If you collect WEEE through curbside collection, please provide the total of the following costs

Suggested items to consider:
Transportation vehicles
Gasoline and fuel for the vehicles
Employee costs
Logistic and planning costs

Total Bulky Waste Collection Costs	DKK	0
What percetage of your bulky waste collection do you estimate is WEEE?	%	0
Comments on the questions or your answers:		

Miscellaneous (Diverse)

These are activities that do not fit in any of the previous categories

Suggested items to consider:
- Publications (flyers)
- Special Events
- Additional Taxes
- Unforeseen Costs

Total Miscellaneous Costs	DKK	298782.06
Comments on the questions or your answers:		

WEEE Specific Costs (WEEE Specifikke Omkostninger)

These are activities that only regard WEEE and are not shared by other waste streams

Suggested items to consider:
- Educational Events
- Special Collection Events
- WEEE Specific Employee Training
- Miscellaneous

Total WEEE Specific Costs	DKK	0
Comments on the questions or your answers:		

Subtotal WEEE Specific Cost	**0**

Total WEEE Collection Cost	**802836.0013**

Comments on the sheet as a whole:	