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The role of the WEEE collection and recycling system setup on environmental, economic and socio-economic performance

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Summary

This study compares the legislation and how the collection systems for Waste Electrical and Electronic Equipment (WEEE) are practically and administratively managed in Sweden, Norway and Denmark.

The authors have studied legislation on EU and national levels, consulted scientific literature, conducted interviews with key actors within the three systems and analysed environmental impacts using LCA models. One general conclusion is that the countries, despite being geographically close, are quite different both in terms of legislation and in practical implementation and setup of the WEEE collection systems.

With regard to legislation, Norway and Sweden have a longer history of producer responsibility than Denmark, which may explain some structural differences like the number of actors and their internal relationships. Once in place, complex systems and agreements are not easily changed, while new systems can learn from early examples. Both the EU directive and the national legislations are subject to regular updates. New provisions for collection in stores are being implemented in Sweden in October 2015, while in Norway the new WEEE directive is not yet finally approved. The new WEEE directive (2012/19/EU) is implemented in Denmark.

The level of legislative detail is higher in both Norway and Denmark, which makes interpretation easier for the system actors. Denmark has the highest level of detail; governing the roles of actors and the terms for cooperation in the system. Since these details have been developed in cooperation with system actors, they are generally accepted as fair and are not seen as a market barrier. In general, clear and detailed legislation seems preferable, especially with regard to roles of actors and ownership of WEEE.

Another difference is the definitions of “WEEE from households”, where Norway stands out by basing this on the origin of the waste rather than the EEE product function. Norway also includes three additional categories of products in its legislation compared to Denmark and Sweden where the categories from the WEEE directive are used. This means that more EEE is covered by producer responsibility in Norway compared to Denmark and Sweden. The requirements on Producer Responsibility Organisations (PROs) and take-back systems are very high in Sweden and Norway, making it difficult for new actors to enter the market and for producers wanting to take individual responsibility without cooperation with PROs. Some incentives for reuse exist in Norway, where reused volumes are subtracted from the overall collection requirements of the PROs. However, strong promotion of waste prevention and re-use could be improved in all three legislations, since this is key from an environmental point of view. It is also clear that both the European WEEE directive and the respective national legislations were written at a time when all waste was perceived to have negative economic value. Since the value of WEEE depends on material composition and changing market economics, future legislation should aim to be more flexible.

When it comes to system implementation, the key actors in the WEEE legislation in Denmark, Norway and Sweden are very similar on an overall level. The main difference is the additional key actor DPA-System in Denmark, a non-governmental, non-profit company working on behalf of the Danish EPA, to which there is no equivalent in Norway and Sweden. DPA-System has many important tasks related to allocation of WEEE quantities, post adjustment, guidance,

supervision and support to actors within the WEEE system. The allocation made by DPA-System of geographical municipal collection points between producers and PROs is unique for Denmark and eliminates the competition for volumes. Sweden has only two PROs while Norway has five and Denmark four. However, 99% of the Swedish collection is covered by one PRO, making the logistics quite efficient while reducing the competition in the system. Instead, financial clearing based on market shares of the respective PRO members is used at the end of each period. Norway is the opposite, with all five PROs competing for WEEE in the entire system, covering over 3000 collection points. Sweden and Denmark have around 1100 and 400 collection points respectively. The number for Denmark only includes municipal and regional collection points, while numbers for Norway and Sweden include distributors, businesses and other types of points. Clearing between PROs is based on market share in all countries, but can be adjusted based on allocation of WEEE volumes or costs. The allocation of collection points in Denmark may be more difficult in Sweden and Norway due to shifting population densities and larger distances. As long as these differences are compensated for, volume based clearing seems to be preferable together with allocation of municipal collection points, at this increases the efficiency in the system. However, this requires a strong third party and clear rules that are accepted by the actors. An open question is whether or not to differentiate between historic and new WEEE in the system.

The payment models and fees paid by the producers to the PROs vary to a large extent, both within and between the countries. Fees can be based on value, mass, units, environmental hazard etc. This is part of the competition between the PROs. Also the setup between the municipalities and PROs vary between the countries. In Sweden, the municipalities are paid by the PROs in order to collect the WEEE, while in Norway and Denmark this work is supposed to be covered by the municipal waste fees.

Norwegian statistics on EEE put on market are best in class due to the fact that they are gathered by the customs on a monthly level, which eliminates the issue of free-riders. The overall collection rate for WEEE from private households lies around 60 percent for both Denmark and Norway, whereas the collection rate in Sweden was almost 80 percent in 2013. It is important to remember that statistics do not cover all WEEE flows, such as business to business volumes and that figures are not readily comparable due to national differences in definitions, reporting procedures etc.

In summary, there is a lot to be learned from the three systems, and the report provides a number of observations and suggestions regarding how to create an efficient and fair system. The authors would like to express their gratitude to all involved actors who have been very helpful during the project.

Sammanfattning

Denna studie omfattar en jämförelse av lagstiftning och praktisk implementering av insamlingssystem för elektronikavfall (WEEE) i Sverige, Norge och Danmark.

Författarna har studerat lagstiftning på EU-nivå och nationell nivå, konsulterat vetenskaplig litteratur på området, genomfört intervjuer med nyckelaktörer inom de tre systemen och analyserat miljöpåverkan med hjälp av LCA modeller. En generell slutsats är att det finns stora skillnader mellan länderna både när det gällande lagstiftning och praktisk implementering av insamlingssystem för WEEE.

Norge och Sverige har en längre historia av producentansvarslagstiftning än Danmark, vilket kan förklara vissa strukturella skillnader som antalet aktörer och deras interna relationer. Etablerade komplexa system och avtalsförhållanden är inte enkla att ändra på, medan yngre system kan lära av tidiga exempel. Både EU-direktivet och de nationella lagstiftningarna uppdateras regelbundet. Nya bestämmelser för insamling i butiker börjar gälla i Sverige oktober 2015 och i Norge har det nya WEEE-direktivet ännu inte godkänts. Det nya WEEE-direktivet (2012/19/EU) är dock redan implementerat i Danmark.

Detaljnivån i lagstiftningen är högre i både Norge och Danmark, vilket gör tolkningen lättare för systemets aktörer. Danmark har den högsta detaljnivån; med styrning av såväl aktörernas roller som villkoren för samarbete i systemet. Eftersom dessa detaljer har utarbetats i samarbete med systemaktörerna, är de allmänt accepterade som rättvisa och ses inte som marknadshinder. I allmänhet verkar tydlig och detaljerad lagstiftning vara att föredra, särskilt när det gäller frågor som rör aktörers roller och ägandeskap för WEEE.

En annan skillnad är definitionerna av "WEEE från hushåll", där Norge utmärker sig genom att grunda detta på avfallets ursprung snarare än på produktens funktion. I Norge omfattas även tre ytterligare produktkategorier av lagstiftningen jämfört med Danmark och Sverige som använder kategorierna i WEEE-direktivet. Detta innebär att mer elektronik omfattas av producentansvaret i Norge jämfört med Danmark och Sverige. Kraven på producentansvarsorganisationer (PROer) och insamlingssystem är mycket höga i Sverige och Norge, vilket gör det svårt för nya aktörer att etablera sig på marknaden och försvårar för producenter som vill ta individuellt ansvar utan samarbete med PROer. Vissa incitament för återanvändning finns i Norge, där återanvända volymer subtraheras från PROers insamlingskrav. Främjandet av förebyggande av avfall och återanvändning bör dock förstärkas i samtliga tre lagstiftningar, eftersom detta är mycket viktigt ur miljösynpunkt. Det är också tydligt att såväl EU-direktivet som nationell lagstiftning skrevs på en tid då allt avfall ansågs ha negativt ekonomiskt värde. Eftersom värdet av WEEE beror av materialsammansättning och föränderlig marknadsekonomi bör framtida lagstiftning sträva efter att vara mer flexibel.

När det gäller systemimplementering är nyckelaktörerna i Danmark, Norge och Sverige väldigt lika på en övergripande nivå. Den största skillnaden är DPA-System i Danmark, ett icke-statligt, icke-vinstdrivande företag som arbetar på uppdrag av det danska naturvårdsverket, vilket inte har någon motsvarighet i Norge och Sverige. DPA-System har många viktiga uppgifter i samband med tilldelningen av WEEE-volymer, volymjustering, tillsyn, vägledning och stöd till aktörer inom WEEE-systemet. DPA-Systems fördelning av kommunala insamlingspunkter mellan producenter och PROer är unik för Danmark och eliminerar konkurrensen om

volymerna. Sverige har bara två PROer medan Norge har fem och Danmark fyra. Dock sköts 99% av den svenska insamlingen av en PRO, vilket gör logistiken mycket effektiv men samtidigt minskar konkurrensen i systemet. Istället tillämpas finansiell clearing baserat på respektive PROs marknadsandel i slutet av varje period. I Norge råder en omvänd situation; alla fem PROer konkurrerar om WEEE i hela systemet, som omfattar över 3000 insamlingsplatser. Sverige och Danmark har omkring 1100 respektive 400 insamlingsplatser. Siffran för Danmark omfattar endast kommunala och regionala insamlingsplatser, medan siffrorna för Norge och Sverige även inkluderar distributörer, företag och andra typer av insamlingsplatser.

Clearing mellan PROer baseras på marknadsandelar i samtliga tre länder, vilket sedan korrigeras i efterhand via fördelning av WEEE-volymer eller kostnader. Den fördelning av insamlingsplatser som sker i Danmark kan vara praktiskt svårare att genomföra i Sverige och Norge på grund av skiftande befolkningstäthet och större avstånd. Under förutsättning att man kan kompensera för dessa skillnader, verkar volymbaserad clearing att föredra tillsammans med fördelningen av kommunala insamlingsplatser, då detta ökar effektiviteten i systemet. Det krävs dock en stark tredje part och tydliga regler som är accepterade av aktörerna. En öppen fråga är ifall det är viktigt med särskiljning mellan historiskt och nytt WEEE i systemet.

Finansieringsmodeller och avgifter som betalas av producenterna till PROer varierar i stor utsträckning, både inom och mellan länderna. Avgifter kan baseras på materialvärde, massa, antal produkter, miljöfarlighet etc. Detta är en del av konkurrensen mellan PROer. Även samarbetet mellan kommunerna och PROer varierar mellan länderna. I Sverige får kommunerna betalt av PROer för att samla in WEEE, medan detta arbete i Norge och Danmark skall täckas av de kommunala avfallsavgifterna.

Norsk statistik över EEE som sätts på marknaden är mycket komplett eftersom informationen samlas in av tullen på månadsbasis, viket minskar problemet med “free-riders”. Den totala insamlingsnivån för WEEE från privathushåll ligger på cirka 60 procent för både Danmark och Norge, medan insamlingsnivån i Sverige var nästan 80 procent under 2013. Det är viktigt att komma ihåg att statistiken inte omfattar alla WEEE-flöden, såsom ”business-to-business”-volymer och att siffrorna inte är direkt jämförbara på grund av nationella skillnader i definitioner, rapporteringsförfaranden med mera.

Sammanfattningsvis finns det mycket att lära av de tre systemen, och rapporten redovisar ett antal synpunkter och förslag kring hur man skapar ett effektivt och rättvist system.
Författarna vill uttrycka sitt varma tack till alla de aktörer som bidragit med värdefull kunskap under projektet.

1 Definitions

For the purpose of this report, the following definitions apply.

Clearinghouse is a function that monitors and coordinates allocation of WEEE collection between the producers. It may also include geographical allocation of collection points.

Collection means the gathering of waste, including the preliminary sorting and preliminary storage of waste for the purpose of transport to a waste treatment facility (in accordance with the Directive 2008/98/EC).

Collection point is a point in which WEEE is collected. It covers everything from small cabinets such as the "Röda boxen" and "Samlaren" to recycling centres.

Distributor means any natural or legal person in the supply chain, who makes an EEE available on the market. This definition does not prevent a distributor from being, at the same time, a producer (in accordance with the WEEE Directive 2012/19/EU).

EEE used by consumer means EEE that typically could be used in private household. Still it is not restricted to private persons only as also commercial, industrial, institutional and other sources may use EEE that could be used in private household (e.g. computers, telephones, answering systems, fax, printers etc.).

EEE intended for professional use means EEE that typically not is used in private households, e.g. automatic dispensers, radiotherapy equipment etc..

Electrical and electronic equipment (EEE) means equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such current and fields and designed for use with a voltage rating not exceeding 1000 volts for alternating current and 1600 volts for direct current. (in accordance with the WEEE Directive 2012/19/EU).

Extended producer responsibility (EPR) is an environmental policy approach in which a producer's responsibility for a product is extended to the post consumer stage of the product's life cycle, including its final disposal" (Widmer et al., 2005).

Financial guarantee: A guarantee that ensures funding to take care of products that have been put on the market when they have become waste.

Free rider is a person or a company who put EEE on the market but is not registered to the EPR system.

Historical WEEE: EEE that has been put on the market before 13 August 2005 and that has become WEEE (Khetriwal et al., 2011).

New WEEE: EEE that has been put on the market after the 13 August 2005 and that has become WEEE (Khetriwal et al., 2011).

Producer means 1) anyone that manufacturers and under his/her own name sell EEE. 2) anyone that under his/her own brand sell EEE. 3) Anyone that import and then sell EEE. 4) Anyone that sells directly to a user in another country in EU (in accordance with the homepage at Elektronikåtervinning i Sverige).

Producer responsible organisation (PRO) fulfil the EPR obligations of their members by organizing pick-up of waste from designated public and distributors collection points, ensuring subsequent treatment and recycling, and performing reporting to national governments (Mayers, 2007).

Recovery means any operation primarily using waste for a useful purpose by replacing other materials, which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy (in accordance with the Directive 2008/98/EC).

Recycling means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations (in accordance with the Directive 2008/98/EC).

Recycling center is a site where waste is collected and often sorted for processing. It is usually open to the public for personal deposit. These facilities usually handle metals, plastics, paper, cardboards, wood, hazardous waste and organic waste.

Recycler company is a company that pre-treats and/or recycles and/or processes waste material.

Re-use means any operations by which products or components that are not waste are used again for the same purpose for which they were conceived. (in accordance with the Directive 2008/98/EC).

Transporter is a company undertaking professional transport of goods.

Waste electrical and electronic equipment (WEEE) means EEE, which is waste, i.e. any substance or object which the holder discards or is required to discard, including all components, sub-assemblies and consumables which are part of the product at the time of discarding (in accordance with the Directive 2012/19/EU and 2008/98/EC).

WEEE from private households means waste of EEE used by consumers. WEEE from private household could come from private persons as well as commercial, industrial, institutional and other sources. It is the product in itself and not who has used it that matters (in accordance with the WEEE Directive 2012/19/EU).

WEEE from other than private households means WEEE, originating from EEE intended for professional use.

2 Introduction

2.1 Background

Electrical and electronic equipment (EEE) such as computers, TV-sets, fridges and cell phones pervades modern lifestyles but its quick obsolescence is resulting in huge quantities of waste electrical and electronic equipment (WEEE) (Khetriwal et al., 2011). WEEE typically includes a diverse range of materials potentially harmful to humans and the environment but is also regarded as a resource of valuable metal (Friege et al., 2015). The amount of WEEE is growing faster than any other waste category in the world. Material recycling is not done sufficiently. Collection, treatment and recycling of WEEE is essential to improve the environmental management, contribute to circular economy, and enhance resource efficiency.

Europe is many times said to be "leading the way" when it comes to WEEE collection and recycling, mostly due to the directives on WEEE (Ongondo et al., 2011). The first WEEE Directive entered into force in February 2003 (2002/96/EC) and requires producers in the EU member states (MS) to take back their products from consumers and ensure their disposal through environmentally sound methods (Widmer et al., 2005). In December 2008, the European Commission proposed to revised the Directive to tackle the rapidly increasing waste stream and the new WEEE directive (2012/19/EU) became effective on 14th of February 2014. It concerns various actors involved in the life cycle of electrical and electronic equipment (EEE) (Sander et al., 2007) such as producers, municipalities, recyclers, producer responsible organizations (PRO), transporters and consumers. The WEEE directives are however not without shortcomings and have attracted criticisms with regard to clarity of the law and how the directives have been transposed in the member states (Khetriwal et al., 2011). The result is 27 different pieces of legislation with varying definitions, obligations and agreements. There are currently more than 150 different producer responsible organisations (PRO) in Europe, making it difficult to follow the actual performance of the overall system (Friege et al., 2015).

This report focuses on the transposition and implementation of the WEEE directive in Denmark, Norway and Sweden. Experiences from ongoing projects (LogiWEEE[1] and SmartEEre[2]) have shown that there are major differences in the set-up of the WEEE systems, e.g. financial and operational responsibility, number of PRO, material and payment flows, and clearinghouse models. At the same time, the Nordic countries are often seen as "best in class" when it comes to collecting and recovering WEEE. According to the WEEE statistics (Eurostat 2012) Norway, Sweden and Denmark are the top three countries (in this order) in Europe when it comes to kg WEEE collected per inhabitant. Since the three countries are anticipated to make changes in line with the new WEEE directive (2012/19/EU), there is an excellent window of opportunity to investigate pros and cons of various WEEE system set-ups and how these differences influence environmental, economic and socio-economic performance. This knowledge is not only of interest for the actors in the Danish, Norwegian and Swedish WEEE systems but may be used as an indication for best practice in Europe and for other products under extended producer responsibility (EPR) schemes.

[1] LogiWEEE is a Vinnova funded project. The goal us to contribute to higher transport efficiency and lower costs for the Swedish collection system of WEEE and increase environment and resource efficient on a system level. KPI for system and transport efficiency has been identified and evaluated of the Swedish WEEE system.
[2] SmartEEe Returtransport is a research project financed by the Norwegian Research Council and the participating partners. http://smarterelogistikk.no/ It evaluates and develops the WEEE system in Norway and the runs in parallel with LogiWEEE.

2.2 Objective and structure of the report

The overall objective of this project is to describe and compare the performance of the Danish, Norwegian and Swedish WEEE system set-ups and provide important input to designing a suitable way of cooperation for all involved actors in the WEEE system. The relationships between actors are extremely important for the performance of EPR schemes (Friege et al., 2015). Studies show that coordination between PRO, distributors and municipalities is a necessity (ibid). In order to fulfil the overall objective seven steps have been carried out and are presented in the report.

- ***Mapping and comparison of the legislation of WEEE in Denmark, Norway and Sweden***. The legislation is described and the effects of the legislation on the WEEE system set-up is discussed. The mapping and comparison of the legislation is presented in Chapter 3.

- ***Mapping and comparison of legislation implementation in practice in Denmark, Norway and Sweden***. The implementation in terms of infrastructure, material, information and payment flows is described and analysed. Pros and cons of the respective implementation are discussed and factors are identified that explain why the systems are designed and operated the way they are. The mapping and comparison of the implementation of the WEEE legislation is presented in Chapter 4.

- ***Clearinghouse models***. The clearinghouse models used in Denmark, Norway and Sweden are described and analysed. Effects of the clearinghouse model on the WEEE system and pros and cons of respectively clearinghouse model are discussed. Furthermore factors influencing allocation of WEEE are identified. The description and analysis of the clearinghouse models are presented in Chapter 5.

- ***Data on EEE placed on the market and treatment of WEEE***. Statistics on EEE put on the market, collection and treatment of WEEE for Denmark, Norway and Sweden respectively is presented by year, EEE-category, tonnes, percent and per inhabitant. A discussion on the statistic figures is given; in particular the gaps in the statistics are identified and estimated. Data on EEE placed on the market and treatment of WEEE is presented in Chapter 6.

- ***Environmental assessment***. The environmental impacts of WEEE products are described and the WEEE fractions, which are most important to recycle, are identified. The share of transport loads compared to the total environmental benefit is also assessed in Chapter 7.

- ***Recommendations***. Recommendations for the design and improvement of an efficient, fair and feasible WEEE system are given in Chapter 8.

2.3 Methodology

Different methods for data collection and analysis have been used in this report.

- During the project we have scanned previous literature such as scientific journals, PhD theses, business-oriented publications, directives and regulations and webpages. The literature review has been conducted continuously throughout the project and has supported in constructing interview guides, agree upon definitions, giving a structure for the analysis and reporting and provided the authors with background information.

- Semi-structured interviews with actors involved in the WEEE system has been carried out: EPA, competition authority, PROs, municipalities, recycling companies, producers, transporters and distributors. The interviews have increased the knowledge about the pros and cons of the WEEE systems and how the legislation was actually implemented in practice. After the completion of the interviews, they were typed up and sent to the interviewees for validation. Each interviewee's response has been triangulated with answers from other participants and thereafter used as follow-up interviews to clarify differences.

- Two workshops have been carried out within the project in which all actors involved in the project have been invited. Representatives from all countries and almost all actors groups (EPA, competition authority, PROs, municipalities, recycling companies, producers) have participated in the workshops. During the first workshop (18 of March) the literature review and the output from the interviews so far were presented and the participants were divided into small groups in which they discussed proposed definitions and related questions to the presented material. In the second workshop (8 of June) the authors started up by a short presentation in which they presented the analysis of the material. The participants thereafter discussed pros and cons of each WEEE system and related questions to the material presented. The workshops has been very valuable to ensure that the authors understanding of the systems but also to let the many actors be able of discussing issues related to the setup of the different systems.

- Life Cycle Assessment (LCA) was used to assess environmental impact of WEEE products. Based on two studies by WRAP (Haig et. al. 2012) and MIT (Boustani et.al. 2010), the content of different WEEE fractions were modelled using the GaBi 6.4 software. Environmental impacts studied were Global Warming Potential (GWP) in a 100 year perspective, primary energy, abiotic resource depletion, human and freshwater toxicity and Photochemical Ozone creation potential (POCP). The impact assessment model CML2001 (CML 2013) was used for calculation of impacts. The primary energy needed to produce the materials in each category was also calculated. More details of the LCA methodology are found in chapter 7.

The input from literature review, interviews, LCA models and workshops has been used for the analyses. Typically the authors have developed detailed case stories for each WEEE system individually and then met face to face to discuss the WEEE systems based on a structure derived from the literature. Consequently, patterns have been compared and contrasted in a cross-case analysis were differences and similarities were noted. In the report the analyses are presented at the end of each chapter, e.g. there is one analysis of the legislation, one of the implementation, one of the clearing models and one of the statistics. In order to keep the actors anonymous they are referred to as interviewees in the report.

3 Transposition of the WEEE directive into national legislation

3.1 The legislation in Denmark

3.1.1 Background

The WEEE directive was implemented in Denmark in 2005 through an amendment to the Danish Environmental Protection Act and the WEEE Statutory Order (Elektronikaffaldsbekendtgørelsen) hereafter called the Danish WEEE Order. Before the implementation 273 local authorities (98 authorities after a local government reform) were responsible for collection and treatment of WEEE in their respective area. Producer responsibility on EEE was a result of the directive and non-existing in Denmark before the WEEE directive (DPA-System, 2015a).

The directive was implemented in several steps where the first step, rules on marking of products, was implemented in 2005. At the end of 2005 the second step was imposed leading to company registration in the producer register of DPA-System, and the third step meant that producers no later than 31 March 2007 were to report quantities placed on the market, taken back, and treated in the previous calendar year in the register (DPA-System, 2015a). The new WEEE Directive (2012/19/EU) was implemented in Denmark in February 2014, and lead to changes in the WEEE order (Miljøstyrelsen, 2015a).

The Danish WEEE Order covers the 10 categories[3] of EEE as defined in the WEEE directive, both "EEE used by consumers" and "EEE intended for professional use". The two use cases are defined in accordance with the WEEE directive i.e. it is the product category rather than the final user of WEEE that determines how WEEE is managed, both in terms of administration and practically. EEE used by consumer products are typically used in households but is not restricted to household use, whereas EEE intended for professional use is typically not used in households. As a result, waste from EEE used by consumer can arise in households as well as in businesses and is defined as WEEE from private households. Waste of EEE intended for professional use mainly comes from business and is defined as WEEE from other than private households.

The major criticism against the current Danish WEEE legislation extracted from the interviews is that the aim of the WEEE directive, to increase resource-efficient and influence on the production of EEE and product design, is not fulfilled by the implementation of the WEEE directive in Denmark. There are no market incentives for EEE producers to make their products more resource-efficient.

Producers are welcome to charge purchasers of their products with the cost associated with the producer responsibility, but the fee is not allowed to be "visual" towards the consumer. This is a result of the Danish environmental protection act (Miljøbeskyttelsesloven), §9 where it is stated

[3] Large household appliances, Small household appliances, IT and telecommunications equipment, Consumer equipment and photovoltaic panels, Lighting equipment, Electrical and electronic tools (with the exception of large-scale stationary industrial tools), toys, leisure and sports equipment, Medical devices (with the exception of all implanted and infected products), Monitoring and control instruments, Automatic dispensers.

that companies must not make consumers of EEE for private households aware of the costs associated with waste management.

3.1.2 Roles of the actors according to legislation

The key players in the Danish WEEE system are the Environmental Protection Agency (EPA), DPA-System, producers of EEE, PROs, and municipalities.

The Environmental Protection Agency:
The Danish Environmental Protection Agency (EPA) executes the political decisions of the Danish government and parliament, and prepares the decision basis for the Minister for the Environment (The Ministry for the Environment and the Danish EPA, 2009). The Ministry of the Environment has the overall responsibility for the statutory basis, interpretation and implementation of the WEEE directive, which in practice is performed by the EPA. This means that the EPA implements the European WEEE legislation in Denmark, influences decisions concerning WEEE on the European level, and conducts supervision over DPA-System, the PROs, free riders and quantities of EEE put on the market. The EPA also has an important role as responsible for development and interpretation of the administrative framework of DPA-System. Finally, the EPA reports data needed to follow-up the targets in the directive to Eurostat. 1.5 fulltime positions at the EPA are dedicated to the work with EEE and WEEE (Miljøstyrelsen, 2015b).

The supervision conducted by the EPA is often executed irregularly as campaigns. A couple of years ago the EPA screened business sector registers in search for producers not registered to DPA-System. The introduction of new products, such as electrical bikes or solar panels, can also result in targeted supervision in order to inform about the producer responsibility and the obligations following the responsibility. The DPA-System website contains a “whistleblower” application where anyone can report producers that are under suspicion of not fulfilling their producer responsibility (Miljøstyrelsen, 2015b).

If a producer does not fulfill its producer responsibility, despite information from the EPA, will be charged. The charges can result in fines of minimum 5000 DKK. Decisions about whether a producer is covered by producer responsibility are thus taken by DPA-System (Miljøstyrelsen, 2015b).

DPA-System:
DPA-System (Danish Producer Responsibility System) is a non-governmental, non-profit company working on behalf of the Danish EPA. A number of tasks in the WEEE Order are dedicated to DPA-System based on instructions from the EPA. DPA-System is responsible for administrative tasks associated with the rules on producer responsibility regarding WEEE, end-of-life batteries, and end-of-life vehicles on behalf of the EPA. The main tasks of DPA-System concerning WEEE is to manage a producer register and administer a producer responsibility scheme providing open competition for the players involved (DPA-System, 2015b). The tasks of DPA-System are believed to be more effectively carried out by an independent, specialised organisation than by a division of the EPA (DPA-System, 2015c).

The board of DPA-System is elected by the Minister of Environment and consists of representatives chosen by the trade organisations DI Dansk Erhverv, Batteriforeningen, De

danske bilimportører, FEHA (Foreningen af Fabrikanter og Importører af Elektriske Husholdningsapparater), VELTEK (VVS og el-tekniske leverandørers brancheforening) and FABA (Foreningen af fabrikanter og importører af elektriske belysningsarmaturer). DPA-System has six employees in total.

EEE producer:
According to the WEEE Order the producer is always responsible for complying with the producer responsibility towards authorities and DPA-System. The producer may turn to PROs (kollektiv ordning in Danish) to practically and administratively fulfill their producer responsibility, or comply with the producer responsibility individually. If the PROs do not fulfill the producers' tasks according to the WEEE Order it is the responsibility of the producer.

Producers must report the following information to DPA-System no later than the 31th of March each year, as stated in the WEEE Order:

- Quantities of WEEE that the producer has taken back and treated
- Environmentally approved facilities having treated the WEEE
- Rates for recycling and preparing for re-use obtained at the different environmentally approved facilities
- Recycled quantities and the quantities prepared for re-use at the different environmentally approved facilities

Producers of EEE used by consumer are bound to take back their respective market share as WEEE from private households. The quantity to be collected by each producer is allocated by DPA-System on an annual basis. Only WEEE from private households is part of the allocation. Producers of EEE for professional use can take back WEEE from other than private households by:

- picking up WEEE at the final user
- accepting final users to deliver WEEE from other than private households to a treatment facility
- a distributor

Producers of EEE must provide financial guarantees for EEE used by consumer according to the WEEE order.

PRO:
PROs offer their services to producers of EEE to help them fulfil their producer responsibility. How the PRO is organised, including ownership, corporate form, nationality, physical location and services offered, is not regulated by law. The only statutory requirements for PROs are that they must be registered to DPA-System with a name, a postal and electronic address and a telephone number. PROs should ensure that every producer can register on the same premises, and be treated on equal grounds, thus respecting the producer's market share (§ 52).

A PRO can undertake the majority of tasks under the producer responsibility on behalf of their registered producers. According to the WEEE Order the PROs can undertake the following tasks for producers:

- Register the producer in the DPA-System producer register, and undertake annual reporting to DPA-System.

- Provide financial guarantee for the quantities of WEEE allocated by DPA-System.
- Enter into agreement with municipalities about collection of WEEE, and report the agreements to DPA-System.
- Collect and treat the allocated quantities of WEEE from private households from municipal collection sites.
- Establish regional collection points and report them to DPA-System.
- Pay administrative fees to DPA-System.

PROs enter into agreements with transporters and recycling companies of WEEE to practically collect and treat the WEEE in line with the rules in the WEEE Order.

Municipalities:
Municipalities are obliged to set up collection points for citizens from where producers or PROs can pick up WEEE from private households on behalf of their registered producers. There are no requirements on the number of collection points. The municipalities must register the collection points to DPA-System by providing the following information:

- The address of the collection site
- Contact information
- Period for pick-up of WEEE
- Any special issues concerning access to keys etc.
- Collection equipment per fraction

According to the WEEE Order, the municipalities are obliged to collect/separate collected WEEE in six fractions:

Fraction 1: Large household appliances
Fraction 2: Cooling appliances
Fraction 3: Small household appliances
Fraction 4: Screens & monitors
Fraction 5: Lamps/light sources
Fraction 6: Photovoltaic panels

Distributors:
Distributors are not allowed to sell EEE from producers who are not registered in DPA-System's product register. Distributors may receive WEEE from private households, but are not obliged to accept it. If a distributor agrees to take of WEEE from private households she/he may only charge payment for management of waste on the premises of the final user and transport from the premises of the final user. If a distributor receives WEEE from private households, the distributor shall use a PRO established by producers or by a municipality meaning that the distributor shall leave WEEE from private households to municipal collection points or to PROs' regional collection points. Distributors can also accept WEEE from other than private households on a business-to-business level.

3.2 The legislation in Norway

3.2.1 Background

The WEEE directive in Norway was first implemented through "Avfallsforskriften" (Waste regulation, hereafter called the Norwegian WEEE order) in year 2006. However, already in 1999, the Ministry of Environment made a voluntary agreement with the Electric and Electronic industry and Business Sector in Norway, which resulted in an EPR system for WEEE financed by the manufacturers and importers of EEE. Even earlier, in 1976, the Product Control act was created in Norway, which can be regarded as a forerunner of putting the EPR principle into legislative context (Goodship and Stevels, 2012).

It should be emphasised that the new WEEE Directive (Directive 2012/19/EU) is about to be implemented in the Norwegian legislation. On December 9th 2014, a draft revised WEEE order (Høring av forslag om endring av avfallsforskriften kapittel 1 om EE-avfall (2013/4639)) was sent on public hearing with due date March 10th 2015. Based on the comments and feedback from the public hearing, the Ministry of Environment is expected to send a proposal for a new WEEE order to the Ministry of Climate and Environment, either before summer or early autumn 2015. It is, however, difficult to estimate how much time the Ministry of Climate and Environment will need in order finally approve the new WEEE order (Brytningsvik, 2015) which means that it is currently not known when the finally approved new WEEE order will enter into force.

The Norwegian WEEE order covers the 10 categories of WEEE as described in the WEEE Directive and includes EEE used by consumer and EEE intended for professional use. However, the WEEE Directive's category 5 (lighting equipment) is divided into 2 separate categories (lighting equipment and light sources). Thus, the 10 categories equal 11 categories in the Norwegian legislation. In addition, the Norwegian legislation covers the following three categories: "Cables and conductors", "Electrotechnical equipment" and "Fixed equipment for heating, air-condition and ventilation".

The Norwegian legislation differs to some extent from the definition in the WEEE Directive in terms of final user of EEE. The WEEE Directive defines WEEE from private households according to its intended use and not according to whom is generating the WEEE, but the Norwegian WEEE order defines WEEE from private households according to where the WEEE is generated. Household waste means waste from private households. Industrial waste means waste from public and private enterprises and institutions (The Norwegian WEEE order (§1-3), 2006).

However, according to the draft revised WEEE order, some new definitions about EEE have been added: EEE intended for professional use means EEE that is only suitable for professional use. EEE used by private households means EEE that typically could be used in private household and by companies, institutions, etc. This means that the definition of EEE in the new draft WEEE order seems to be in line with the WEEE Directive (2012/19/EU), while the definitions of WEEE from households and public/private companies, respectively, still depends on where the waste is generated, and therefore do not equal the definitions in the WEEE Directive (2012/19/EU).

3.2.2 Roles of the actors according to legislation

The key players in the Norwegian WEEE –system are the Environmental Protection Agency (EPA), the EEE producers, PRO, distributors and the municipalities. The following descriptions of the duties of the different actors refer to the current Norwegian WEEE order (Norwegian Waste Regulation, Chapter 1, 2006),

Environmental Protection Agency (EPA):
The Norwegian Environment Agency (Miljødirektoratet, here EPA) is the regulator of the WEEE system and responsible for ensuring that producers fulfill their responsibilities. EPA approves the PROs and may revoke the authorisation if an approved PRO does not meet the requirements in the legislation. If a PRO loses its authorisation, it is required to treat the collected WEEE according to the existing requirements.

EPA has established the WEEE Register (EE-registeret) in order to follow up reporting and statistics about domestic producers and importers of EE equipment, as well as collected amounts of WEEE. The data from the register, which is owned by EPA but operated by a consultant, is used as basis for the EPA reporting of official national statistics to the European Commission every year.

The WEEE Register provides an overview of all domestic producers and importers of EEE and provides guidance on their duties. The register also draws up an overview of domestic producers and importers who do not comply with the demands in the Waste Regulations and reports these to the EPA. In addition, the WEEE Register receives and collates data from the PROs to produce statistics regarding collected and treated amounts of EE waste.

The WEEE Register collects data from The Directorate of Customs and Excise containing the following information:

- the importer/exporter identity (VAT number, name, address, etc.),
- what kind of EE equipment that has been imported/exported,
- the mass volumes the value of the EE equipment imported/exported.

In addition, it collects data from the PROs about their members' domestic production of EE-equipment. Based on this information, the WEEE Register establishes a register of producers and estimates the amounts of EE-equipment put on the Norwegian market etc.

About two fulltime positions at the EPA are dedicated to the work with EEE and WEEE (Brytningsvik, 2015). In addition the WEEE register employs 2-3 full time positions (Interviews, Norway).

EEE producer:
All producers who on a commercial basis import into or manufacture EE equipment for the Norwegian market, are required to finance the collection and treatment of EE waste through either membership in a collectively or individually financed PRO that is approved by EPA. Membership in a collectively financed PRO means that the producer enters into an agreement for the purchase of services from an approved PRO, and hand over most of the legal responsibilities to the PRO. Membership in an individually financed PRO means that the domestic producer assumes an individual producer responsibility. There are currently no individually financed PROs in Norway.

The obligation to be a member of an approved PRO applies to producers of both components and products that are EE equipment. The membership shall cover all the categories of EEE imported into or manufactured in Norway, as defined in the WEEE order.

Producers are also obliged to provide information to customers regarding appropriate disposal of WEEE in all of its sales- and information material and wherever else appropriate. The information must indicate where the EE equipment should be delivered for collection, that it is covered by an EPR scheme and that it is received free of charge. The EEE producer should ensure that EEE is labelled with a symbol of a crossed out wheeled bin with a black bar below (which can be replaced by a date), meaning that the product has been placed on the market after August 13th 2005 (according to the Product legislation, § 2a-9).

The producers do not have to register with the national register of producers, as the required data are collected by the WEEE Register directly from The Directorate of Customs and Excise and the PROs.

PRO:
The PRO ensures that their system meets the requirements for an approved take back system and submits the required information to the WEEE register.

In a collectively financed PRO two or more producers finance the waste collection and treatment in proportion to their share of EE equipment put on the market related to the total amount of WEEE generated in the same year. According to The Waste Regulation, the most central duties of a PRO are as follows:

- Be registered as separate legal entity in accordance with Act no. 15 of 3 June 1994 relating to the Central Coordinating Register for Legal Entities.
- Be approved by EPA. To be granted approval, the PRO must document that it fulfils a list of criteria set out in the Waste regulation and be approved by a certification body.
- Ensure that WEEE is transported, treated and disposed of in line with the applicable rules and regulations. This includes i.e. ensuring that hazardous materials and components in the WEEE are sorted and handled at approved treatment facilities.
- Provide information stating that EEE equipment is not to be disposed of together with other waste. This information must also state where the EE equipment in question is to be handed in for collection, that it is covered by an ERP scheme, and that it is received free of charge.
- Cover the costs associated with the operation of the WEEE Register with a contribution corresponding to the market share of all its members in relation to the total supply of EE equipment.
- Report to the WEEE Register:
    - Which producers join or leave the PRO as well as which of the categories of EE equipment are covered by the notifications of producers joining and leaving
    - The total quantity of WEEE that has been collected and treated. Figures shall be broken down according to county of collection, municipality, treatment method, treatment facilities, country (where the WEEE has been treated) and EE categories.

The report shall also show the distribution of WEEE from households and industry respectively.
    - What quantities of EE equipment that are reused. It should be emphasised that reused products have to function according to their original purpose (not be destroyd, thus representing waste). The PROs are required to have a standard procedure implemented in order to test whether or not the EEE product can be regarded as a functional product of which is supervised by the EPA. The amount of reused EEE is withdrawn from the overall collection requirement, thus representing an incentive for increased reuse.
    - The members' total production and export of EE equipment.

- Ensure that WEEE is collected free of charge from distributors and the municipalities.

- At all times have the financial resources to ensure fulfillment of the obligations for its members for a minimum of six months. This requirement represents the PROs obligations with regard to financial guarantees.

- Ensure that the collected WEEE is treated in accordance with the obligations stipulated in § 1-18 in the Waste Regulations.

- Collect and receive WEEE in relevant geographical areas of the country where EE equipment of its members is or has previously been sold or delivered, irrespective of the brand or make of the waste equipment.

- Collect and receive a proportion of the quantity of WEEE collected in total that corresponds to the share of its members in the total supply of goods in the same geographical area. The obligation relating to collection and reception applies to each category of EE equipment. The amount of reused EEE products is withdrawn from the overall collection requirement.

- These requirements are further specified in the certification criteria: The PROs are, during the last 6 months/3 years, required to collect each category of EE equipment in at least 75%/90% of all the municipalities and to collect at least 90%/95% of required volume. The new draft WEEE order suggests some changes with regard to these certification requirements. As an example the requirement of collecting WEEE in 75% of the municipalities during the last 6 months is suggested to be changed to "collect WEEE from all municipalities with more than 5000 inhabitants".

Municipalities:
The municipality shall ensure that a sufficient provision exists for the reception of WEEE and shall receive WEEE from households free of charge. The municipality shall also receive WEEE that is industrial waste, but can demand a charge for the costs associated with the reception and storage of such waste.

The municipality shall ensure that the WEEE is sorted from other waste and stored in a suitable place until it is collected by a PRO or a waste treatment company. The storage method shall not present a risk of pollution or damage to people or animals. The possibility to sort, reuse or recycle WEEE components shall not be reduced. The new draft WEEE Order, however, has removed all references to PROs with regard to collection of WEEE from municipalities. In addition, it suggests new duties and requirements for waste treatment companies with regard to treatment, reporting etc. The new draft WEEE Order also requires municipalities to store WEEE with potential sensitive data in a locked container. The municipality shall inform households

and companies that WEEE is not to be disposed of together with other waste and that it receives WEEE.

Distributor:
The distributors shall receive WEEE from households (similar to products that the distributor sells) free of charge at the shop or nearby. It is also required to receive WEEE from other than households free of charge when an equivalent quantity of new EE equipment is purchased. When EE equipment is sold and/or delivered through a channel outside of the shop premises, including by mail order or via the Internet, the distributor shall establish an effective system for forwarding and receiving similar quantities of WEEE. The distributor shall receive the WEEE free of charge, but can charge costs directly related to the dispatch of EE waste. The price of dispatch the WEEE must not exceed the amount that the distributor requires for dispatch of similar quantities of sold EE equipment.

The distributor shall ensure that the received WEEE is separated from other waste and stored in a suitable place. The storage method shall not present a risk of pollution or damage to people or animals. The possibility that components in the WEEE can be reused, recycled or sorted shall not be reduced. The new draft WEEE Order also requires municipalities to store WEEE with potential sensitive data in a locked container. The distributor shall store the WEEE received until it is collected by a certified PRO. If the WEEE is not collected, the distributor shall contact a PRO in order to arrange for the collection. The PRO may require the distributor to transport the WEEE to a suitable place within reasonable distance from the distributor.

The distributor shall provide information that WEEE should not be disposed of together with other waste and that it receives WEEE. It shall provide this information through notices in all shop premises, display and exhibition premises, at temporary points of sale and in all sales and information material that is published in connection with the sales activities, both in electronic and paper-based media. The text shall be eye-catching and easy to read, and it shall be distinct from other information.

3.3 The legislation in Sweden

3.3.1 Background

The WEEE directive in Sweden was implemented through “Förordningen om producentansvar för elutrustning, 2005:209”, from now on Swedish WEEE order, in 2005. However, EPR for WEEE was introduced already in 2001 (Friege et al., 2015), as a result of a process that started in the beginning of the 90’s. This makes Sweden one of the countries in Europe with the oldest WEEE management system (Khetriwal et al., 2011). The Swedish answer to the new WEEE Directive (2012/10/EU) is the regulation “Förordningen om producentansvar för elutrustning, 2014:1075”, which entered into force on October 15 2014. Many provisions from the previous regulation have been transferred to the new regulation, although there are a series of changes for the actors in the WEEE system.

The Swedish WEEE order includes the 10 categories[4] of EEE as defined in the WEEE directive and covers EEE used by consumers and EEE intended for professional use. EEE used by

[4] large household appliances, small household appliances, information technology, consumer equipment, lighting equipment, electric and electronic tools, toys, leisure and sport equipment, medical devices, monitoring and control instruments, automatic dispensers. Incandescent lamps, luminaries for fluorescent lamps which, large scale stationary

consumer and EEE intended for professional use are defined in accordance with the WEEE directive i.e. it is the product itself and not who has used the product that determines how WEEE is managed, both in terms of administration and practically. EEE used by consumer is typically used in households but is not restricted to households whereas EEE intended for professional use is typically not used in private households. Waste from EEE used by consumer could come from private households as well as businesses and is defined as WEEE from private households. Waste of EEE intended for professional use mainly comes from business and is defined as WEEE from other than private households. The regulation is somewhat different for producers of EEE used by consumer and producers of EEE intended for professional use (see 3.3.2).

Many of the interviewees in the Swedish WEEE system emphasise that the way the WEEE directive and the Swedish WEEE order are formulated does not encourage the manufacturing or import of environmentally friendly products. The WEEE directive does not prevent the generation of waste, but rather makes sure that WEEE is taken care of.

3.3.2 Roles of the actors according to legislation

The key players in the Swedish WEEE system are the Environmental Protection Agency (EPA), producers of EEE, PROs, and municipalities. However, PRO is not mentioned in the Swedish WEEE order; instead the "WEEE take back system" is given a lot of attention and is defined as "professional collection of WEEE from private households". Only authorised WEEE take back systems are allowed to collect WEEE from private households. From the 1st of October 2015 EPA will be responsible for approving WEEE take back systems. At the moment only the two PROs, El-Kretsen and EÅF, are close to fulfilling the requirements of an approved WEEE take back system. Still it is open for other actors (producers, waste companies etc.) in the WEEE system to operate as a take back system (given that they have an authorisation).

Environmental Protection Agency (EPA):
EPA works on behalf of the Swedish government and is the supervisory authority responsible for EPR. This means that EPA should ensure that producers meet their EPR obligations in accordance with the Swedish WEEE order. From October 1st 2015, EPA is responsible for approving WEEE take back systems and may revoke the authorisation if an approved take back system does not meet their requirements. EPA also has the responsibility to inform the public about who has an authorisation to operate a WEEE take back system. Beside operational supervision, EPA has a guiding role and should support consumers, producers, distributors, municipalities and recycling companies in case they have questions about the WEEE system. EPA should ensure that it is possible for producers to make a notification on the webpage and get information on how they can enroll.

EPA is responsible for managing a register (EE-register) with annual reports of the volume/weight of EEE put on the Swedish market and the weight of WEEE that is collected and treated. The official statistics are reported to the European Commission every year.

Fines may be imposed on anyone who intentionally or negligently does not fulfill its obligation of EPR. EPA typically uses administrative punishment by contacting producers that should be registered asking for an explanation. If the producer does not answer it will be charged and

industrial tools, medical devices for implants and/or expected to be infectious before they become waste are not included in any of the categories.

eventually fined. Fines may also be imposed if approved take back systems and producers do not manage the reporting of statistics in a satisfactory manner. According to the regulation on environmental sanctions (2012:259) the fee is 10 000 SEK if take back systems or producers report too late.

There are two employees working 80% with the operational supervision and one full time employee working with the guiding role at EPA.

EEE producer:
A producer that intends to make electrical equipment available on the Swedish market must register to EPA and inform EPA if any changes are made to the information given. The notification should include contact details, identification number, type of EEE, product category, equipment brand, when the equipment will be available on the market and how the producer will fulfill its EPR obligations.

An EEE producer should ensure that EEE put on the Swedish market are manufactured and designed in such a way that reuse and recycling is promoted. This does not apply if a particular manufacturing or design process has decisive advantages with respect to human health, the environment and safety requirements. The EEE producer should ensure that EEE is labelled with a symbol of a crossed out wheeled bin and with data that informs the user that the product has been placed on the market after August 13th 2005.

The obligations of the producer differ somewhat depending on the type of EEE. A producer of EEE used by consumer must ensure that an operator of a WEEE take bake system has committed to take care of the equipment when it becomes waste. The producer must also take responsibility for historical WEEE corresponding to its market share. A producer of EEE intended for professional use does not have to be connected to or operate an approved WEEE take back system. If a producer chooses to take back WEEE individually it must accept WEEE from end users and be prepared to take back WEEE at places with a geographical distribution that is fair according to the life expectancy, use and other circumstances of the product.
The producer of EEE intended for professional use should also:

- provide quality service for end users
- promote preparation for reuse
- ensure that WEEE is collected and treated in a safe, secure and environmentally acceptable manner
- Inform users of the obligation to separate WEEE from other waste and where to hand over WEEE

A producer of EEE intended for professional use does not need to take responsibility for historical WEEE nor depose financial guarantees, which a producer of EEE used by consumer must. At the EPA website[5] there are a number of guides for producer of EEE used by consumer regarding how to ensure financial guarantees. According to the website the calculation of the financial guarantee should take into account the expected product life cycles and the fact that costs of collection and recycling may change. EPA gives four alternatives for financial guarantees:

[5] http://eeb.naturvardsverket.se/ProducentansvarforEE/Finansiella-garantier/

1) Bank guarantee in which the bank, for a fee, guarantees the costs for collection and recycling of a producer's products over the products lifetime plus a year.
2) Insurance solution in which a company ensure that the one taken care of the producers products are receiving a compensation for taken care of the products.
3) Blocked bank account that includes the amount of money needed in order to take care of the products for the product lifetime plus one year.
4) Collective financial solution in which the producers organize themselves and allocate money in a collective funding system.

According to the website these guides are soon to be replaced by a new guidance in which the responsibility of financial guarantees will be passed on to the approved takes back system. EPA is positive to this change as it reduces the workload of EPA.

There are also some differences between producer of EEE used by consumer and producer of EEE intended for professional use when it comes to fees. A producer of EEE used by consumer is not allowed to charge the final user for WEEE collection and treatment whereas a producer of EEE intended for professional use has the possibility to do so. The Swedish WEEE order states that a producer of EEE intended for professional use should receive WEEE without compensation for WEEE management costs "unless otherwise agreed".

When it comes to reporting, a producer of EEE used by consumer shall report yearly the total weight of EEE put on the Swedish market during the previous calendar year to EPA. A producer of EEE intended for professional use shall also report weight per product category collected and treated.

PRO:
In order to collect WEEE from private households an authorisation will be required from October 1st 2015 (the WEEE take back by municipalities and distributors excluded). Authorisation will be granted only for those who have:

1) human, technical, organisational and financial conditions to run a WEEE take back system,
2) entered into agreements with producers or producer representatives permitting management of producer´s WEEE,
3) consulted with municipalities on how the system should be organized and operated.

An approved WEEE tack-back system should be 'appropriate' and 'nationwide'. To be 'appropriate' the following is required:

- Easily accessible collection points where end users can leave their WEEE free of charge.
- A service whereby WEEE from private households received by distributors is picked up free of charge at the distributor's collection point or at a place that the distributor and PRO has agreed upon.
- A service whereby WEEE from private households collected by the municipality, that the municipality want to leave to a PRO, is picked up free of charge at the municipality's collection point or in a place that the municipality and PRO has agreed upon.
- The collection is not carried out in such a way that the preparation for reuse or recycling is hindered.
- There is an adequate security equal to the costs of collecting and recycling WEEE.

- WEEE collected is treated in a safe and environmentally sound manner.
- Operations are conducted so that it contributes effectively to reach the targets for collection and recovery.
- Interactions exist with other approved take back systems on how the costs for collected WEEE from private households will be distributed.
- Routines exist for allocating costs of management of historical WEEE from private households.
- Operations are carried out in a safe and environmentally acceptable manner.

To be considered 'nationwide', there must be collection points in each municipality with a geographical distribution that is reasonable with regard to population density and other factors.

Before applying for authorization, the system should consult with 1) municipality and explain how the system should be organized and operated and 2) other approved WEEE tack back systems to explore the possibilities of coordinating the systems.

System operators shall inform EPA about changes in the system that may affect the assessment of the system adequacy. An annual report should also be sent to EPA before end of March, including information on the producers connected to PRO, collected weight for each product group and treated weight for each product group (prepared for reuse, recycled, recovered in another way and removed). If needed or if the municipality request so, the system operator should consult with the municipality on how the system is organised, run and coordinated with other WEEE take back systems or other significant issues related to the system.

The requirements on an approved WEEE take back system are extensive. According to some interviewees the high requirements (e.g. on geographical coverage) reduce the possibility of new market entry which could discourage local commitment. Still, the interviewees agree that it is dangerous to open up the market completely as there is a great risk for cherry picking, leaving the serious actors with only the costly products. There is also lack of clarity regarding the sentence "… an adequate security equal to the costs of collecting and recycling WEEE" in the Swedish WEEE order. Some interviewees interprets it as if the EPA guides on financial guarantees[6] are passed on to the WEEE take back system whereas other interviewees interpret it as if it is enough that the WEEE take back system has a safe balance sheet. EPA is currently working on a clarification on what is required to become an approved WEEE take back system and exactly what the requirements will be on financial guarantees.

Municipalities:
The Swedish WEEE order refers to the Swedish code "Miljöbalken (1998:808)" when it comes to the responsibility of the municipalities. In "Miljöbalken" it is stated that the municipality is responsible for WEEE from private household in the municipality and should make sure that it is collected and recycled. This responsibility is however restricted by the Swedish WEEE order in terms of waste provided to somebody who is obliged to accept the waste.

Municipalities have shared operational supervision of producers and should make sure that they fulfill their obligations according to the Swedish WEEE order. According to interviews with EPA, the supervision of municipalities is on a local level whereas EPA has the national

[6] http://eeb.naturvardsverket.se/ProducentansvarforEE/Finansiella-garantier/

responsibility. The municipalities shall also ensure that the local collection meets the requirements of accessibility, easy sorting and quality service.

The municipalities are responsible to inform local residents of the obligation to separate WEEE (from private households) from other waste and where to hand over WEEE from private households.

According to the interviewees in the Swedish WEEE system, the division between municipalities and producers is not totally clear, in particular regarding who should be financially responsible for the collection within the municipalities. The Swedish WEEE order could be interpreted as municipalities having the right to receive, collect, recover WEEE from private household but not the obligation to do it. Consulting the WEEE directive (2012/19/EU) does not help to clarify this. Here it is stated that "producers should provide at least for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE from private household that has been deposited at collection facilities" (hence someone else may be financially responsible for the collection facilities). Furthermore it is stated "Member states may, where appropriate, encourage producers to finance also the costs occurring for collection of WEEE from private households to collection facilities".

Distributor:
A distributor of EEE used by consumer is, when supplying new products, responsible to ensure that waste from such products can be returned to the distributor free of charge on a one-to-one basis as long as the equipment is of equivalent type and has fulfilled the same functions as the supplied equipment. Besides, distributors with a retail shop with EEE related sales areas of at least 400m^2 should provide for consumers to submit WEEE free of charge if the product has external dimensions not exceeding 25 cm in length, width or depth.

Distributors must inform consumers that waste (as described above) can be returned. Furthermore, distributors who receive WEEE must leave the WEEE to an approved WEEE tack back system. These obligations apply from October 1st 2015.

Many actors welcome the changes in the Swedish WEEE order as it will most likely make it easier for consumers to hand in WEEE, resulting in higher collection rates. They stress that Sweden is developing towards urbanization and that people in cities do not always have access to cars for travelling to recycling centers (that are geographical dispersed and relatively few). However, the obligation for distributors to take back WEEE has a downside. According to interviewees it will result in increased transportation work and a risk that WEEE is left at collection points where no one would like to collect it. As such it is important to choose strategic locations where volumes can be large enough to financially justify pick up.

3.4 Comparison of the legislation in Denmark, Norway and Sweden

The WEEE directive is differently implemented in Denmark, Norway and Sweden. To begin with, producer responsibility obligations on EEE were implemented in Norway and Sweden long before the WEEE directive was introduced, in 1999 and in 2001. Producer responsibility on EEE in Denmark was implemented when the WEEE directive came into force. This might be the reason why historical WEEE is not addressed in the Danish legislation whereas it is addressed in

Norway and Sweden. The new WEEE directive (Directive 2012/19/EU) is implemented in Denmark and Sweden, but the implementation process in Norway is not yet finalised.

A general observation in the respective WEEE orders is that they all lack apparent incentives for contributing to sustainable production and consumption of EEE by, as first priority, the prevention of WEEE. This is a main purpose of the WEEE directive. The focus in the current national legislations is put further down the value chain, when EEE has become WEEE and on how WEEE should be administered and treated.

Different levels of detail

The Danish and the Norwegian WEEE orders are remarkably detailed in comparison to the Swedish counterpart. As an example, the Danish and Norwegian WEEE orders have 34 pages compared to Sweden's 19 pages, which of course is an imprecise measurement, but still gives an indication. The Danish WEEE order includes detailed guidelines and instructions on how municipalities and PRO:s must cooperate, details about producer fees to DPA-System, how the allocation of WEEE quantities among producers is performed, and the different actors' roles and responsibilities in the management of EEE and WEEE. The Danish WEEE order also includes an appendix where the cooperation between municipalities and producers is described and stated. This appendix was added to the WEEE order as a support to municipalities and producers. Besides, DPA-System has developed a high number of guidance documents to facilitate the interpretation of the legislation. The documents are available to everyone on the DPA-System web page.

The actors in the Swedish WEEE-system encourage more detailed explanations of the different actors' roles in the legislation. The lack of clarification causes uncertainties and difficulties with interpretation of the responsibilities for the actors involved. Unclear legislative constructions could be partly compensated by strong support in the interpretation of legislation by the responsible authorities. In Sweden, such support is not seen as satisfactory and the system actors call for more guidance.

A disadvantage with a high level of detail could be limited flexibility for actors in the WEEE-system. However, no such indications have been found in the interviews with the Danish and Norwegian key players. The situation seems to be the opposite; the high level of detail is seen as positive and beneficial for the overall system.

Definitions of EEE and WEEE

When it comes to the definitions of different kinds of WEEE, Norway stands out by using other definitions than those described in the WEEE directive. Instead of defining WEEE from private households regardless of the final user (a private household or a business) the legislation in Norway takes into consideration where the WEEE is generated. Household waste means waste from private households and industrial waste means waste from public and private enterprises and institutions. The draft revised WEEE order (public hearing until March 10th 2015) includes definitions of EEE in line with the WEEE directive, while definitions of WEEE from households and public/private companies are suggested to remain the same as today. Another difference in the Norwegian WEEE legislation is the number of EEE product categories. The addition of three categories makes the statistics more detailed and results in more EEE products covered by producer responsibility in Norway than in Sweden and Denmark. Furthermore, the Danish WEEE order states that collection of WEEE from private households from municipal collection

points must be carried out in six WEEE fractions as opposed to Norway and Sweden where no such requirements are in place.

3.4.1 Roles of the actors according to legislation

The key actors in the WEEE legislation in Denmark, Norway and Sweden are on an overall level very similar. The main difference is the additional key actor DPA-System in Denmark, a non-governmental, non-profit company working on behalf of the Danish EPA, to which there is no equivalent in Norway and Sweden.

Responsibilities for implementation of legislation
Denmark, Norway and Sweden have in common that the respective EPAs are overall responsible for the statutory basis, interpretation and implementation of the WEEE directive. In Denmark a number of administrative tasks associated with the WEEE legislation are transferred from EPA to DPA-System. The tasks of DPA-System are described in the Danish WEEE order, and are exclusively given to DPA-System. It is unusual that tasks and responsibilities are allocated to a specific organisation. The tasks include administrating an EEE product register, clearing of WEEE quantities to be taken back by EEE producers/PROs and allocation of municipal collection points to producers/PROs. In Norway and Sweden the product register and other administrative tasks are managed by the EPAs, while clearing in Sweden is not carried out by EPA, but by the PROs before the result is subject to third party auditing.

The amount of resources dedicated to administrative tasks associated with the WEEE legislation also differs. The Danish EPA employs 1.5 fulltime positions dedicated to work with EEE and WEEE together with six fulltime positions at DPA-System (also handling end-of-life vehicles and batteries). In Norway two full time positions are dedicated to EEE and WEEE at the Norwegian EPA, and in Sweden there are two people working 80% with the operational supervision and one full time employee working with the guiding role at EPA. Even though it is difficult to compare the amount of resources dedicated as the positions certainly differ in structure and tasks, it is possible to conclude that more resources is allocated to administration and guidance in the Danish WEEE system compared to the Swedish and Norwegian.

EEE producers
Some interesting differences regarding reporting obligations for EEE producers are seen in the three countries. In Norway, as opposed to Denmark and Sweden, producers of EEE do not have to register quantities put on market as the required data is taken directly from customs statistics. Data is transferred to the WEEE register from the customs statistics on a monthly basis. In Denmark and Sweden there is no supervision from any authority on the registered amount. However, according to the revised Danish WEEE order, all electrical equipment placed on the market from the reporting period of 2015 must be authenticated by the management or an auditor. The requirement of the auditor's attestation differs depending on the producer's obligation to draw up financial statements and have them audited, as well as the annual turnover. Producers fulfilling certain criteria, as stated in the WEEE order, are exempted from attestation from auditors. Despite these requirements, the accuracy of data in Norway is considered to be higher than in Denmark and Sweden.

According to literature, EEE producers that are active in several markets typically need to declare different types of data to different organisations at different intervals, as no standard reporting format or criteria exists (Khetriwal et al., 2011). The reporting requirements seem

rather similar in Denmark and Sweden, while Norway stands out as producers are not asked to directly report anything to a national register.

In Denmark and Norway producers of EEE have the option to fulfil the requirements in the WEEE orders by taking their producer responsibility individually, or by transferring some of the tasks to PROs. The Norwegian requirements on approved collection systems are strict enough to unable individual producers to comply individually in practice. In Sweden it is compulsory for producers of EEE used by consumer to be connected to an approved WEEE take back system (which in practice is two PROs), which producers of EEE for professional use are not obliged to. Having an obligation to become a member of a PRO or by other means unable producers to take individual responsibility limits the options to fulfill the producer responsibility from the producers' point of view. Systems where producers have the option to fulfill their duties individually seem preferable and more flexible as long as the producer requirements are equal.

The use of visible fees on EEE for private households is allowed in Norway and Sweden, but not in Denmark. Norwegian and Swedish producers do not use this right and the fees associated with the producer responsibility are included in the market price of the products, and not separately presented. The marking of EEE products placed on the market with a crossed wheeled waste bin and with data that the product has been placed on the market after August 13th 2005 is compulsory in all three countries (after April 1st in Denmark). Still, Sweden is the only country where this actually matters as historical and new WEEE are separated from each other in the clearing mechanism. In Denmark, WEEE without a bin symbol is managed the same way as WEEE with the symbol.

Producers of EEE must provide financial guarantees according to Danish, Norwegian and Swedish legislation. The requirement is only valid for producers of EEE used by consumer in Denmark and Sweden, whereas all types of EEE are covered in Norway. In Norway, PRO:s must provide financial guarantees covering six months of business according to the legislation. In Denmark the financial guarantee should cover the collection of the allocated amounts of WEEE from private households for the allocation period of 12 months, but PROs can be exempted from providing financial guarantees if they fulfill certain criteria listed in the Danish WEEE order. The Swedish WEEE order only states that producer of EEE used by consumer must provide financial guarantees but not how it should be done in detail. Still at the webpage at EPA there is a number of guides for financial guarantees[7]. From the 1st of October the requirements of financial guarantees for producers is passed on to the WEEE tack back system but exactly what the requirements on financial guarantees will look like is not known.

PROs

In Norway there are authorization requirements to be fulfilled by PROs who want to set up a WEEE collection system. In Sweden these requirements apply to the WEEE take back system, which may be a PRO or another actor that fulfills the requirements. In Denmark the focus of the requirements is not the WEEE take back system, but primarily producers and municipalities. There is therefore no authorisation of WEEE take back systems or PROs. None of the countries have legislative intervention on the PROs' business models including ownership, corporate form, statues, nationality and physical location. The Norwegian legislation includes requirements around the management of EEE reuse. The amount of reused EEE are withdrawn from the overall collection requirement of the PRO providing incentives for increased reuse.

[7] http://eeb.naturvardsverket.se/ProducentansvarforEE/Finansiella-garantier/

Municipalities
In Denmark and Norway, as opposed to Sweden, municipalities must establish collection points for collection of WEEE from their citizens. The Swedish WEEE order could be interpreted as municipalities have the right but not the obligation to collect WEEE from private households. There are no requirements on number of collection points per citizen or similar.

Municipalities in the three countries have no right to compensation for their WEEE collection according to the legislation. In Denmark municipal collection points must be registered to DPA-System whereas in Norway and Sweden registration of municipal collection points are not carried out. In Denmark, DPA-System decides which PRO/producer that will collect WEEE from each municipal collection point, whereas municipalities in Norway and Sweden have the right to make the decisions themselves The Danish WEEE order states that WEEE must be collected in six fractions at the municipal collection points, whereas no such detailed description is to be found in the Norwegian and Swedish counterparts.

Distributors
Danish distributors of EEE have the right to collect WEEE from private households, but are not obliged to do so. In Norway the distributors must receive WEEE from private households similar to their sold products free of charge; the same principle will be applied in Sweden from October 1st 2015. WEEE from other than private households must be accepted in Norway if an equivalent amount is purchased. From October 2015 Swedish distributors with an EEE sales area of at least 400 m^2 must provide the possibility for consumers to hand in WEEE of certain sizes free of charge. In Denmark and Sweden the take-back of WEEE from other than private households by distributors is not regulated by law.

4 Implementation of the WEEE directive in practice

4.1 Implementation in Denmark

4.1.1 Background

There are currently four PROs in Denmark; Elretur, ERP Denmark, RENE and LWF (Lyskildebranchens WEEE Forening). LWF is only focusing on light sources, and the other three on all EEE categories. LWF and Elretur are non-profit associations, while ERP Denmark and RENE are commercial.

4.1.2 Material flows

There are a limited number of treatment facilities of WEEE in Denmark, and it is mostly pre-treatment and dismantling of WEEE that occurs, not actual end-of-life operations. The responsibility for supervision of the treatment facilities lies on the municipalities. The individual members in charge of the supervision are often responsible for different types of organisations and sectors, and without specific expertise in WEEE treatment, why it could be challenging to observe irregularities. Together with a complex legislation and limited resources for supervision, the quality of the supervision could be questioned. Insufficient supervision may favor illegal activities (from interviews).

WEEE from private households
WEEE from private households is collected through three main routes. The primary one, already mentioned, is collection from municipal collection points in six fractions. In 2013 there were 397 municipal collection sites registered in DPA-System (DPA-System, 2014a). PROs or producers are allocated quantities of WEEE from private households to collect at municipal collection points on an annual basis. The quantities are calculated by DPA-System based on the registered producers' market share of EEE used by consumer. Currently there are no individual producers allocated municipal collection points, only PROs. The cooperation between PROs and the municipalities is regulated in a separate appendix in the WEEE Order. The minimum collection frequency is stated for each of the six WEEE fractions, and detailed instructions are given on how the communication between the municipality and the PRO (or in practical terms the transporter collecting on behalf of the PRO) should be organised. The municipality sends a request to the PRO's contracted transporter when the fractions need to be collected. The request must be submitted no later 2 p.m two weekdays before desired pick-up. Pick-up must be effectuated no later than two weekdays after receipt of the request, but the PRO and the municipality can agree on a permanent time for pick-up. Municipalities also have the right to request so-called emergency pick-ups where the request must be submitted one day in advance of the requested pick-up. According to the WEEE Order, each collection point is allowed to request 12 extraordinary pick-ups during an allocation period. The right for the municipality to request collection at short notice occasionally makes the logistics inefficient, and the costs for collection are not always covered for the transporters (interviews).

Companies are allowed to deliver WEEE from private households to the collection points if they are the final users of the WEEE. Companies using municipal recycling points not only have to be final users of WEEE, but do also have to pay an annual fee to the municipality according to the

Waste Order. The annual fee allows companies to use the municipal collection points in the actual municipality.

The second route is that WEEE from private households is taken back by distributors (§ 22 in the WEEE Order) on a voluntarily basis. Both companies and private households can leave WEEE from private households to distributors of EEE. In reality, this option of collection is minor as the municipal collection points are the basis in the collection system for WEEE from private households. The distributor may only charge payment for the management of waste on the premises of the final user and transport from the premises of the final user. In practical terms this means that a company being the final user of WEEE from private households may deliver it to the distributor of the EEE, and may only be charged for the transport and management of WEEE on their premises. According to the legislation, distributors shall leave their accepted WEEE from private households to the municipal collection points or to the regional collection points. This is, according to DPA-System (2015d), however not always the situation as distributors often sell the collected WEEE directly to waste companies.

The third route is collection of WEEE from private households through regional collection points established by PRO. Each PRO is obliged, according to the WEEE Order, to establish regional collection points in every region and accept WEEE according to fractions that the members of the PRO shall take back. This option is possible for WEEE from private households, independent on the final user. Even though the regional collection points welcome private households, it is doubtful that households use the route as the municipal collection points are the number one alternative for the citizens, and the option communicated by municipalities (DPA-System, 2015d).

Apart from the main routes, generators of WEEE from private households make arrangements with waste companies/transporters that deliver the WEEE directly to treatment without involvement of any producer or PRO. These flows are not registered in the official DPA-System statistics.

WEEE from other than private households
The main route for WEEE from other than private households is that producers of EEE for professional use make an agreement with the purchaser that the purchaser overtakes the producer responsibility (§ 36, Chapter 10 in the WEEE Order). The purchaser then contracts a waste company for collecting the WEEE at its end-of-life. This is the main route for WEEE from other than private households, and data is not covered in the official DPA-System statistics (DPA-System, 2015d). Other routes for WEEE from other than private households are collection at regional collection points. WEEE from other than private households is to some extent also collected at municipal collection points, but is then registered as WEEE from private households DPA-System, 2014a).

4.1.3 Financial flows

Producers of EEE must be registered to DPA-System and pay an annual fee to DPA-System. The fee consists of a one-off registration fee of DKK 1000, and an annual fee covering the DPA-System's administration of reported quantities and calculation of the allocation of WEEE from private households. The annual fee is set per kg placed on the Danish market reported to DPA-System. The fees for 2014 are presented in **Table 1**(DPA-System, 2015e).

Table 1. Annual fees covering DPA-System's administrative costs (DPA-System, 2015e).

EEE	Per kg (DKK)	Per tonne (DKK)
for professional use	0,0249	24,90
used by consumer	0,0325	32,50

The size of the fee is annually approved by the board of directors of DPA-System and the Ministry of the Environment. The fee is calculated based on DPA-System's budget divided by the quantities of EEE placed on the Danish market in the previous calendar year. The fee for EEE for professional use is lower than EEE used by consumer due to the fact that WEEE from other than private households is not part of the allocation made by DPA-System. The producers or the PROs on behalf of their registered producers are obliged to report the quantities of EEE placed on the market, the collected amounts of WEEE and the treated amounts of WEEE per product category for the previous year to DPA-System. The reporting should be made between January 1st and March 31st each year (DPA-System, 2014f).

Producers registered to PROs are charged for the collection, treatment and administration associated with producer responsibility. The PROs are actors on a competitive market and their business models vary, both "pay-as-you throw" and "pay-as-you sell" concepts exist. As the business models are not official it is not possible to compare the difference in price for the producers depending on the PRO they register to. The agreements between the PROs and the producers are on commercial grounds with no intervention from DPA-System. The PROs enter into agreements with transporters and recyclers of WEEE. The transport and treatment services can be procured together or separately (interviews).

The municipalities get no financial compensation for their collection of WEEE. The collection of WEEE is financed through the municipal waste fees that are charged the citizens. As the municipalities are not compensated for their efforts they have no or limited incentives to increase collection of WEEE, an issue that has been raised during the interviews.

When DPA-System has made the allocation of WEEE from private households all municipalities are informed by email. The information is sent to the overall email address of the municipality as well as to the email addresses of the specific collection points communicated upon registration of the collection points. The results of the allocation are also sent to the producers registered email addresses, and made public through the website of DPA-System. The communication includes which producer/PRO that is responsible for collection of each of the six fractions at respective municipal collection point. The transporter/recycler contracted by the producer/PRO for collection for each of the six fractions is also made public, if the producer/PRO has informed DPA-System about it (DPA-System, 2014f).

When the allocation of quantities and of municipal collection points is communicated the PRO/producer informs the municipality about who the transporter in charge of the collection will be. The municipality and the transporter make an agreement about the practicalities following the collection, and if they have difficulties with making an agreement, the municipalities turn to the producer/PRO as they are formally responsible for the collection. The agreements should be finalised no later than September 1st (DPA-System, 2014f).

The collection and treatment of WEEE from other than private households are carried out based on agreements on a business-to-business level between waste generators and transporters/recyclers.

Financial guarantees

The financial guarantee must be provided by producers of EEE used by consumer, and should be used if a producer ceases to exist or cannot collect the allocated quantities of WEEE from private households. DPA-System annually calculates management costs per EEE category as basis for the size of the financial guarantee by inquiring reprocessing companies and the PROs. The financial guarantee for 2013 for different EEE categories is presented in Table 2. For the EEE categories not subject to any net management costs no financial guarantee is levied.

Table 2. Costs for 2014 for calculation of the financial guarantee (DPA-System, 2014d).

EEE Category		Cost (DKK/kg)
1	Large household appliances	0.29
2	Small household appliances	0.00
3	IT and telecommunications equipment	0.21
4	Consumer equipment	0.55
5a	Luminaires	0.00
5b	Light sources	11.00
6	Electrical and electronic tools	0.00
7	Toys, leisure and sports equipment	0.00
8	Medical devices	0.00
9	Monitoring and control instruments	0.00
10	Automatic dispensers	0.00

Producers placing such a small amount of EEE on the market that allocation of a collection point is not possible, must provide a financial guarantee for coverage of collection costs to DPA-System. This only occurs if the producer is not registered to a PRO. PROs can get the financial guarantee refunded from DPA-System if they can show that they have collected more than their allocated quantities of the certain fraction and that they have costs associated with this extra collection. If the PROs cannot document their costs associated with extra collection of WEEE the financial guarantee is refunded to the individual producers (DPA-System, 2015e). Criticism has been raised in the interviews that individual producers are favoured in the system, as the size of the financial guarantee does not correspond to collection costs for the allocated amounts. The list prices of DPA-System are the prices the PROs would pay, and that requires certain quantities. DPA-System has never forwarded any financial guarantee from individual producers to PROs, and no PRO has ever presented any documentation to DPA-System that could show an added economic burden stemming from individual producers (DPA-System, 2015c).

PROs can be exempted from provision of financial guarantee if the PRO has at least ten registered producers and the total market share of the producers registered to the PRO makes up at least 5 % of the total quantity of EEE in kilograms placed on the market within one of the categories reported for all producers. Besides, a PRO exempted from financial guarantee in one of the categories 1-7 is exempted in the other categories. PROs can apply for exemption to DPA-System for one allocation period at a time (DPA-System, 2014e). Currently all PROs have applied for exemption, which has also been approved.

Producers can join the clearinghouse model individually or as a member of a PRO. All producers of EEE for private households should be connected to the clearinghouse model and are required to register administrative information to DPA-System and report annual quantities of EEE put on the market and taken back.

4.2 Implementation in Norway

4.2.1 Background

As described in chapter 3.2.1, the Ministry of Environment made a voluntary agreement with the Electric and Electronic Industry and Business Sector in Norway in 1999. As a result, an EPR system for WEEE financed by manufacturers and importers was established (Goodship and Stevels, 2012) and the two non-profit PROs Elretur and RENAS were established. Elretur was responsible for WEEE from households while RENAS should take care of WEEE from business. However, after the implementation of the WEEE Directive (2003) through the Waste Regulation in 2006, both Elretur and RENAS have covered all WEEE product categories. In addition, three business-based PROs have entered the market: Eurovironment AS, EPR Norway AS and Elsirk AS. Currently, five PROs operate more than 3000 collection points, representing a variety of single end-consumers (customers), distributors, large municipal collection points, as well as the PROs own collection points. All PROs cover all of the EEE product categories. Elretur is owned by the Norwegian EE suppliers Foundation (NEL), ICT Norway, and Abelia, while RENAS is owned by The Electro Association (EFO) and the Electro and Energy Federation of Norwegian Industries. Eurovironment is fully owned by Elretur while Elsirk is owned by RagnSells AB. ERP-Norway is the Norwegian part of the pan-European European Recycling Platform (ERP), which was established in 2002 by Braun, Electrolux, HP and Sony.

4.2.2 Material flows

There are a limited number of treatment facilities of WEEE in Norway, mostly dealing with treatment and dismantling of WEEE, not actual end-of-life operations. The responsibility for supervision of the treatment facilities lies on the Environmental Protection Agency.

The municipalities are responsible for collecting WEEE from households while the PROs have a duty to collect WEEE free of charge from the municipalities. The municipalities are free to decide how the WEEE collection should be organised from their household; some choose to offer both a kerbside collection system (e.g. red box for small WEEE and hazardous waste) with an added system for delivery of WEEE at municipal collection points/recycling centres, while others offer only delivery systems. However, the municipalities have a duty to store the WEEE separated from other waste fractions before it is collected for treatment. As a second collection route, households can also deliver their WEEE free of charge to all distributors where the PROs further collect it free of charge. These possibilities are also available for companies. However, companies may be charged a fee at the municipal collection points and their WEEE can only be delivered free of charge to a distributor if an equivalent quantity of new EE equipment is purchased. It has been estimated that about 40% (30 000 tonnes) of the total collected WEEE from households take the route through distributors (Wiik Svendsen, 2015). Companies can also deliver WEEE free of charge directly to the PROs' own collection points. In total, more than 3000 collection points exist in the Norwegian system.

As the PROs are actors on a competitive market and their business models vary, the agreements between PROs and transporters/treaters vary between the PROs and may also vary around the country. The frequency of pick-up of WEEE is determined in the specific agreements between the PROs and municipalities/distributors.

As described in chapter 3.2.2, all the PROs have a duty to collect and treat their members' respective share in proportion to total collected WEEE volumes. However, in order to fulfil these duties, they have to compete about "getting access" to the generated WEEE, especially from large municipalities. This has resulted in specific agreements between PROs and large municipalities, as these are the "low hanging fruits" in the system. On the other hand, there have been examples of "left" WEEE, not being collected at collection points in rural areas. As clarified in the new drafted WEEE Order, the municipalities are free to choose whether they make agreements with PROs or with other actors with permission for treatment and with formal duties/requirements for treating WEEE. The importance of placing equal requirements on these other actors as on the PROs, however, should be emphasized (The Norwegian PROs 2015, Norwegian interviews, 2015, Gulbrandsen et al., 2014). This is important to secure that WEEE is collected and treated by serious actors and to avoid "cherry picking".

In reality, the PROs and transporters/treaters in urban areas already compete about the same WEEE volumes today. However, the transporters/treaters need a contract with a PRO in order to be paid for treating the WEEE (with negative values). Thus, there is a risk that treaters are left with such "negative valued" WEEE when the PRO's obligation has been fulfilled. Since only 90% of the obligation needs to be fulfilled for PRO certification, this represents a realistic case. On the other hand it may not be that interesting for a transporter/treater to link the treatment of positive valued WEEE to a PRO, which means that these volumes may be missed in the statistics. This also inclines a potential loss of profit for the PROs. However, the new drafted WEEE Order suggests new requirements for all treaters including reporting of treated volumes per product groups, material etc., thus reducing potential statistical gaps.

In addition to the official routes through collection sites provided by municipalities, distributors or PROs, some WEEE (mostly positive value WEEE) may also pass the official system through unknown actors (Norwegian interviews, 2015). It should also be mentioned that unknown amounts of WEEE take more unofficial routes (such as theft), ending up at the illegal market.

4.2.3 Financial flows

All producers/importers of EEE (within the 14 product categories included in the Norwegian WEEE order) have to be members of an approved PRO (either collectively or individually financed) and pay their fee to the respective PRO. This fee shall finance the collection and recycling of their EEE put on the market after becoming WEEE. About 5000 members are registered to the PROs (WEEE register, 2015).

The fees for the producers/importers are based on different approaches. Some PROs calculate the fees as a percentage of the products' net import value, while others base their fees on product weight and/or the number of products put on the market. The fee may also be affected by the products environmental hazard and/or recycling difficulties. The pricing of the environmental fees represents one part of the competition between the PROs. The financial guarantees are indirectly included in the fee for all PROs in Norway as the PROs are obliged to, at all times, have the financial resources to ensure fulfillment of the obligations for its members for a minimum of six months.

The costs for organizing/collecting WEEE from households into the municipal collection points are intended to be covered by the municipal waste fees, which are levied in all households. Some PROs may however pay the municipalities for sorting, dependent on agreed sorting requirements (different WEEE categories). As a results of the competition between the PROs to get access to the WEEE (mentioned in chapter 3.2.2), specific payment agreements have been established between PROs and large municipalities. This means that the PROs pay the municipalities for their WEEE (Konkurransetilsynet, 2015).

In contrast to WEEE generated by private households, WEEE generated from business may be subject to charges when delivered to a public recycling centre. Further, WEEE from business can only be delivered free of charge to a distributor if an equivalent quantity of new EE equipment is purchased. Companies can, however, deliver WEEE free of charge to collection points set up by "their" PRO's.

The PROs purchase transportation and recycling services on a business-to-business level on the market, using individual contracts.

4.3 Implementation in Sweden

4.3.1 Background

In 2001, when EPR for WEEE was introduced in Sweden, the PRO "El-Kretsen i Sverige AB" and Swedish municipalities started a collaboration called "Elretur" (Sveriges Rikstad; 2012:1). Elretur can be seen as the foundation of the Swedish WEEE system and states that municipalities account for the collection of WEEE from private households and El-Kretsen for all other expenses ensuring treatment of WEEE from private households, in accordance with the legislation (Naturvårdsverket report 5969, 2009). Thus, El-Kretsen ensures the collection of WEEE from private households in each municipality which is necessary according to the Swedish WEEE order. The contract between El-Kretsen and the Swedish municipalities was originally written in 2001 and has been frequently renewed since then. The current contract applies from 2013 to 2018. Before 2010 the contract was based on a shared responsibility in which municipalities were financially and operationally responsible for collecting WEEE from

private households within the municipality while El-Kretsen was financially and operationally responsible for the transportation of WEEE from municipalities' large collection points (such as recycling centres and similar) to pre-treatment facilities, as well as the recycling activities. In the current contract the operational responsibility is divided in the same way as before but El-Kretsen pays a compensatory fee to the municipality for the WEEE they collect.

In 2007, the PRO "Elektronikåtervinning i Sverige" (EÅF) entered the market. EÅF has established collection points at their members' stores (Årsredovisning, 2013, EÅF). As those stores are not represented in all municipalities, and as El-Kretsen is the exclusive contract partner to municipalities, El-Kretsen and EÅF have entered an agreement (Naturvårdsverket report 5969, 2009). In this agreement El-Kretsen and EÅF share the costs of collection and recycling of WEEE, i.e. financial clearing (see chapter 5.3).

El-Kretsen and EÅF are both non-profit and non-governmental PROs. El-Kretsen is owned by trade associations and EÅF is owned by EEE producers. El-Kretsen takes care of collection and recycling of all product categories except product category 10 (automatic dispensers) and EÅF of all product categories. Both PROs also take care of collection and treatment of batteries. El-Kretsen collects WEEE from around 1000 collection points whereas EÅF collects WEEE from 126 collection points. In addition to collection and recycling of WEEE on behalf of the producers, taking care of historical WEEE, and reporting to EPA what has been collected and treated every year, El-Kretsen and EÅF offer solutions for financial guarantees. El-Kretsen has many producers (1602) representing the majority of the quantities of EEE put on the market whereas EÅF has fewer producers (70) but relatively large volumes (about 25% of the market) (Årsredovisning 2013, El-Kretsen, Årsredovisning 2013, EÅF).

4.3.2 Material flows

Recycling companies in Sweden typically take care of pre-treatment, dismantling and end-of-life operations. The responsibility for supervision of the treatment facilities lies on the Environmental Protection Agency.

WEEE from private households
WEEE from private households is collected through three main routes. The primary one is collection from municipal collection points and the majority of the volumes come from the around 590 recycling centers. Municipalities sometimes offer their citizens several options for delivering WEEE, such as small collection points placed in connection to grocery stores, gas stations and recycling centers. Businesses have the option to deliver WEEE from private households to at least one municipal collection point free of charge.

Municipalities are free to decide how the collection within the municipality is organised; some municipalities choose to outsource the collection whereas other municipalities keep it within the organisation. El-Kretsen takes over the responsibility of WEEE at the municipalities' large collection points. WEEE is organised in the following product groups; various electronics, light bulbs, refrigerators and freezers and large household appliances. El-Kretsen has contracts with about 30 transporters that pick up WEEE at municipal collection points and transport it to the about 30 pre-treatment facilitates in Sweden. In order to communicate with transporters, municipalities and personnel at the pre-treatment facilities, El-Kretsen has a joint Enterprise Resource Planning (ERP)/ordering planning system called "Ataio".
The personnel at the collection points report inventory levels in Ataio and transporters plan

their routes based on this information. By help of a personal digital assistant (PDA) and bar codes it is registered in Ataio when the driver enters and leaves a collection point. When the material arrives to a pre-treatment center it is weighed and the order is closed in Ataio.

The second route of WEEE from private household is take back by producer themselves through their EEE stores. Both El-Kretsen and EÅF pick up WEEE from their members´ stores where private persons as well as businesses can hand in WEEE. This flow is expected to increase from October 1st 2015, when distributors (no matter if they are producers or not) will be responsible for taking back WEEE. In the cases where El-Kretsen is responsible for the collection and recycling from stores, the procedure described above is used, i.e. material is transported to pre-treatment facilities by transporters and taken care of by recycling companies, and the ERP system Ataio is used as a communication and transport planning tool. In the cases where EÅF is responsible for the collection and recycling, the recycling companies Stena Technoworld or Ragn-Sells take care of the collection and recycling. EÅF has a direct contract with Stena and an indirect contract with Ragn-Sells[8]. Stena takes care of the collection at all stores except from Elgiganten where Ragn-Sells are used. Stena uses a concept called “green collect” where transporters pick up WEEE in stores when there is space in the truck to avoid unnecessary transport. It normally takes a few days after placing an order in Ataio until the order is picked up.

The third route is collection of WEEE from private households at a business-to-business level. The transporters contracted by El-Kretsen pick up WEEE at real estate companies, authorities and other enterprises and transport it to pre-treatment facilities where recycling companies make sure that the WEEE is handled according to the legislative requirements. Many actors are active in handling this flow, including municipal collection companies, waste companies and recycling companies. The Swedish WEEE order states that only approved WEEE take-back systems and municipalities are allowed to collect WEEE from private households. When other actors enter, they either cover the costs of handling the WEEE that PROs already have been paid for (by their connected producers) or make profits from the WEEE that the PROs should have made. According to interviewees this is not a big problem as long as those other actors take care of the WEEE in accordance with the directive. Still, from a statistical point of view it becomes a dilemma as waste companies and recycling companies typically do not report their collected volumes to EPA.

There has been some confusion of who has the right to collect WEEE from private households from businesses. One reason, according to interviewees, is the unclear definition of WEEE from private households in the WEEE directive. Before the new WEEE directive, it was easy to interpret WEEE from private households as only including WEEE generated by private households and not by businesses. Many interviewees ask for clarification in the Swedish WEEE legislation when it comes to the responsibility of WEEE from private households from businesses and private households. The opinions differ; municipalities typically would like more municipal responsibility and recycling companies and waste companies typically think that the collection of WEEE on a business-to-business level should be managed through the free market.

WEEE from other than private households

WEEE from other than private households is usually collected by waste companies and recycling companies at the final users on a business-to-business level. It is also possible for the final user to leave WEEE from other than private households at some municipal collection points and at

[8] EÅF has an agreement with Elgiganten, which has an agreement with RagnSells.

stores. According to interviewees, large volumes of WEEE from other than private households end up in the system of EÅF and El-Kretsen although the producers of EEE intended for professional use are not connected to either of the PROs.

Besides the three main routes, i.e. municipal collection points, stores or directly at businesses some WEEE is subject to illegal export to countries outside of Europe. The purpose of exporting WEEE is to reduce recycling costs. The control and regulation in Europe is much stricter than in many other countries, thus there is an opportunity to increase the profit margin by using cheaper recycling (or non-recycling) options.

4.3.3 Financial flows

Producer of EEE used by consumer
Producers of EEE used by consumer must be connected to an approved WEEE tack back system, in practice El-Kretsen or EÅF. At El-Kretsen, the producers pay a fee based on the number of products put on the market each month multiplied by the costs for collecting and recycling. The collection and recycling costs for different products are calculated based on a pre-established price list of current costs, and a final settlement is made in connection to the final accounts. If metal prices increase producers may get money back at the end of the year. Regarding financial guarantees, El-Kretsen offers their members a financial solution but accepts solutions consistent with the Swedish WEEE order and EPA general guidelines. El-Kretsen has set aside funds to cover waste for at least one year of operation. Producers at EÅF also pay a fee based on the products put on the market multiplied by a price list reflecting the collection and recycling costs of different products. Consideration is taken to both historical and new WEEE when calculating the fee. The costs of historic waste are based on current collection and recycling costs, shared proportionally according to the producers respectively market shares. The costs of new waste are based on estimated future costs of collection and recycling of the products. Thus the solution for financial guarantee in included in the fee of each product and is differs between products.

El-Kretsen buys the transportation and recycling services on the market. The transporters charge El-Kretsen based on kilometers driven multiplied by the number of cargo carriers collected on a monthly basis. El-Kretsen works with around 9 recycling companies (about 30 pre-treatment centres all together) and basis their payment on material costs, sorting costs, material values and WEEE weight (sometimes they pay and other times they get money back). In cases where El-Kretsen pick up WEEE directly at businesses, the final user may have to pay for the transportation even though the EEE producers have paid for the collection and recycling services through their fee to El-Kretsen. The reason is that the pick up at the businesses door is seen as an extra service. When waste companies or recycling companies pick up WEEE at businesses they may charge for transport and recycling. This means that the final users in those situations pay twice. First they pay for collection and recycling in the purchasing price and then they pay for the collection and recycling when the product has become waste. In addition to transportation and recycling costs, El-Kretsen pays municipalities a compensation fee twice a year per kg WEEE collected within the municipality. El-Kretsen provides the same compensation fee to all municipalities. According to interviewees this is not a perfect situation as it is more expensive for small municipalities than for large densely populated municipalities; thus the fee should be differentiated.

EÅF has contracts directly with Stena and indirectly with RagnSells (see chapter 4.3.2) . EÅF receives an invoice from Stena and Elgiganten every month. In the invoice sent by Stena the costs of transportation and recycling are separated and in the invoice by Elgiganten all costs are lumped together under total cost per product category. EÅF and El-Kretsen share the costs for collection and recycling in a financial clearinghouse (see chapter 5.3).

Producer of EEE intended for professional use

Producer of EEE intended for professional use can decide if they want to be a member of an approved WEEE take back system or organise the WEEE take back themselves. If a producer chooses to be a member of El-Kretsen or EÅF, the financial flow looks the same as for EEE used by consumer. Typically, a producer of EEE intended for professional use pays a higher fee to El-Kretsen and EÅF since the collection and recycling costs for those products are higher. If a producer chooses to organise the WEEE take back himself, this is made though agreements on a business to business level between producer and/or final user and waste companies. According to the legislation, the producers may charge the final user for the collection and recycling service, which in practice means that waste companies typically charge the final user.

According to the actors in the WEEE system there are both pros and cons of the current organisation in which municipalities are responsible for the collection of WEEE from private households and El-Kretsen is the sole actor responsible for the collection from municipal collection points. On the one hand it is possible to build up a good, secure and simple structure; municipalities e.g. mention that it is easy to work with one partner and that the logistical solution is simple. Using one coordinator of the transports creates economies of scale and cheaper transportation. Having one PRO that negotiates with municipalities also results in a strong purchasing position. If many actors purchased the service from municipalities it would most likely be more expensive (which would mean higher costs for producers and in the end for consumers). On the other hand many actors question the competition within the system; it is difficult for other WEEE take back systems to enter the market and for existing WEEE take back systems to operate on the same terms. As an example, EÅF does not have any authority over their volumes, they only have to pay their part. It could be argued that if you are financially responsible, you should also have the right to influence how to handle the material as it has a direct impact on the costs.

Some interviewees also mean that only having one counterpart can make the system very inflexible. E.g. there may be situations when a container is full but El-Kretsen´s transporters do not pick up the material fast enough. In this case it would have been nice if the municipality could bring the container to the pre-treatment centre and get some compensation for this job, which is not possible today. The risk is that new, unserious actors come knocking on the door offering more frequent pick-ups at a higher cost, which may be tempting especially for municipalities where the compensation from El-kretsen does not cover the collection costs. There are also opinions against the monopoly situation of municipalities, stressing that other actors should also be able to provide collection of WEEE from private households within the municipality. Other interviewees think that it is very important that the municipality is responsible for WEEE from private households from households, but that it is important to let the market control the business to business flow (WEEE from private household from businesses and WEEE from other than private households).

4.4 Comparison of the implementation in Denmark, Norway and Sweden

4.4.1 Background

The PROs in the different countries are summarised in the table below.

Table 3. Summary of the PROs in Denmark, Norway and Sweden.

	PRO	Type of PRO	Ownership	Members/ producers	Collected** share 2013	Collection points
DK	elretur	Association, non-profit	EEE producers in the board	Not official	Not official	400+20 (municipal collection points + regional collection points)
	ERP	Commercial	Landbell			
	Rene	Commercial				
	LWF*	Association, non-profit	Producers of light sources on the board			
NO	Elretur	Non-profit	Trade association	4981	25%	About 3000***
	Elsirk	Commercial	RagnSells AB		6%	
	ERP	Commercial			25%	
	Eurovironment	Commercial	Elretur		3%	
	RENAS	Non-profit	Trade association		41%	
SE	El-Kretsen	Non-profit	Trade association	1602	99 %	About 1000****
	EÅF	Non-profit	EEE producer	69	1 %	126

* Lyskildebranschens WEEE Forening, only collecting light sources

** 2013 (collected rates, not taking int account cleared/post-allocated volumes)

*** Municipal, distributors and PROs' own

**** Municipal, distributors and businesses

As seen in the table above, the number of PROs in Norway and Denmark are five and four, respectively, while there are only two PROs in Sweden. There are also large differences between the PROs with regard to collection shares. It should be emphasised that the collection shares may not correspond to market shares in Norway and Denmark, as over- and under-fulfilment of the requirements may have occurred, which have been post-adjusted in 2014. In Denmark, the collection shares between the PROs are not official, but elretur represents the largest market share of EEE used by consumer, based on the number of allocated municipal collection points in 2014 (DPA-System, 2015g).

In Norway, the collection shares vary between 3 and 41% between the different PROs. In Sweden, one PRO collects almost 99% of the total collected WEEE but when looking at the volumes put on the market the market share of EÅF is about 25%, which means that after financial clearing, EÅF has taken responsibility for about 25% of the collected WEEE.

In Norway and Sweden all PROs take care of all WEEE categories while one of the four PROs in Denmark only collects light sources. In Denmark, the collection of WEEE is allocated to the municipal collection points and dedicated to each PRO by DPA-System. In Norway, all PROs have to collect WEEE in all regions where their members put EEE on the market. In Sweden one PRO collects WEEE in all municipalities.

4.4.2 Material flows

The material flows in the three countries can briefly be illustrated as shown in Figure 1.

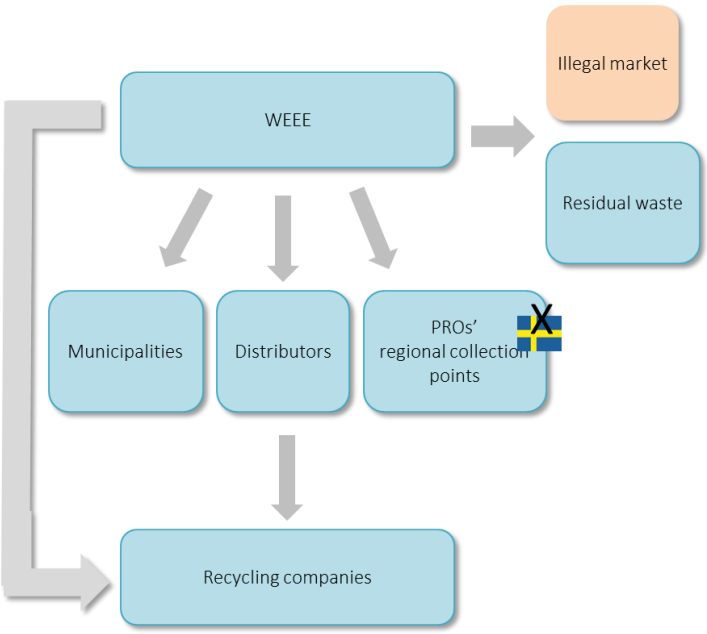


Figure 1. Material flows in the WEEE system.

Sweden is the only country where the PROs don't have their own collection points.

Figure 2 below shows the major collection routes in the different countries with respect to WEEE from private households from households. In all the following figures, only the main flows are presented bearing in mind that WEEE also can take other routes.

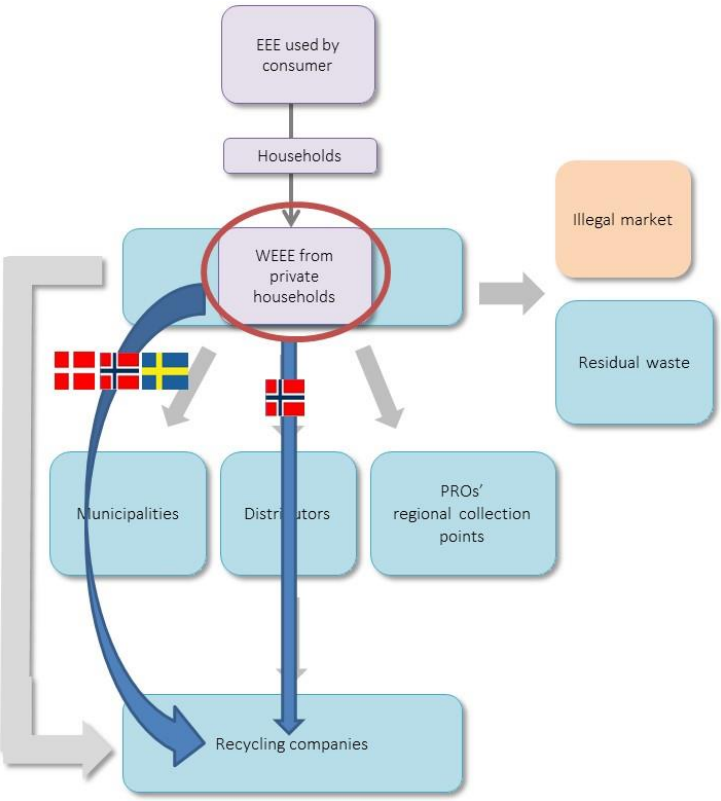


Figure 2. Major material flows for WEEE from private households from households.

The major collection routes for WEEE from private households from households in all the countries are municipal collection points, in particular the recycling centers. However, in Norway, the distributors represent a major collection channel as almost 40% of all collected WEEE from private households are collected through these channels. There is a large variation in the number of collection points in the three countries. In Denmark about 400 registered municipal collection points are operated, in addition to 20 regional collection points, while in Norway and Sweden about 3000 and 1125 collection points, respectively, are operated.

In Figure 3 the major collection routes in the different countries with respect to WEEE from private households from businesses are presented.

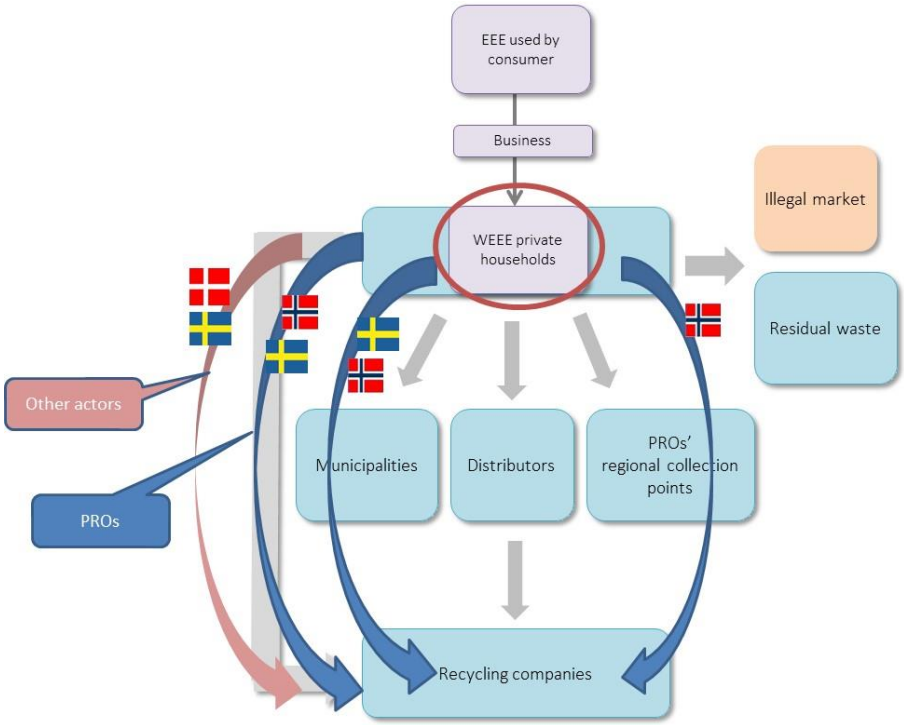


Figure 3. Major material flows for WEEE from private households from business.

The major route in Denmark for these flows is through actors other than PROs transporting the WEEE directly from the companies to recycling sites on a business-to-business level. In Norway, the PROs are the main actors for this flow and a major flow also passes through the municipalities' recycling centers. In Sweden both PROs and other actors are involved in the collection of WEEE from private households from businesses.

Figure 4 below shows the major collection routes in the different countries with respect to WEEE from other than private households.

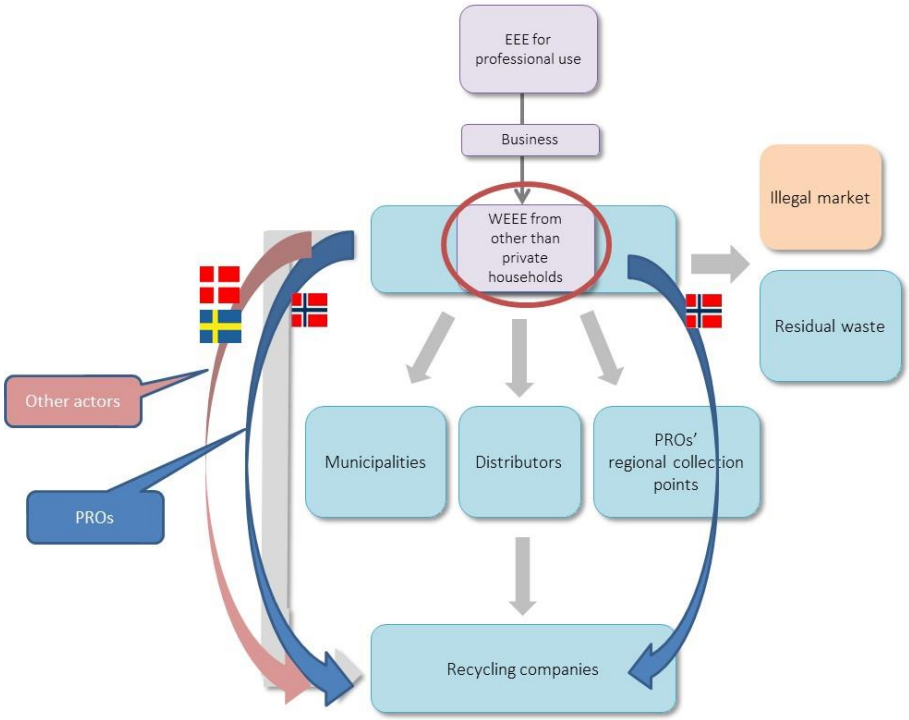


Figure 4. Major material flows for WEEE from other tha private households.

The majority of these flows are in Denmark and Sweden collected directly on a business-to-business level by other actors than PROs (transporters/recyclers) while the PROs still are the main actor also for these flows in Norway (either collected directly from the companies or through regional collection points).

In all the three countries, the PROs enter into agreement with transporters and/or recycling companies of collection and treatment of WEEE. In Denmark, after the geographical allocation has been decided, it is up to the municipalities and the transporters to agree on the practicalities of the WEEE collection. If any problem arises, the municipalities turn to the PROs as they are formally responsible for collection. However, the municipalities can order collection at their collection points whenever needed, as this is stated in the WEEE Order. In Sweden, the ordering planning system "Ataio" decides the frequency of WEEE collection at the municipal collection points while, in Norway, this is up to the respective PRO and their agreement with the transporters.

4.4.3 Financial flows

The financial flows in the three countries are briefly illustrated in Figure 5. All arrows without any flags represent financial flows in all the three countries.

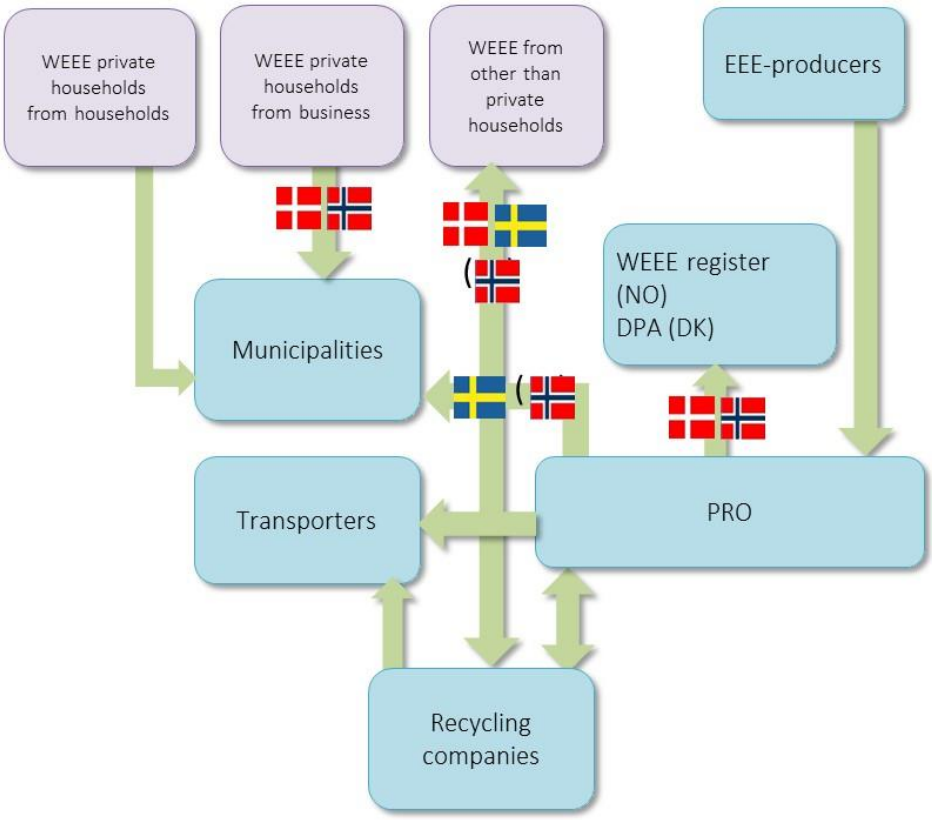


Figure 5. Financial flows in the WEEE system.

In Denmark and Norway, respectively, DPA-System and the WEEE register are financed by the producers. In Denmark, the producers have to pay a one-off registration fee in addition to the annual fee based on EEE put on the market to DPA-System, while in Norway and Sweden the producers only pay fees to their PROs (no administrative fees). However, in Norway the PROs cover the costs for the WEEE register, which means that the producers indirectly pay for the services provided by this register.

The payment model and fee paid by the producers to the PROs vary to a large extent, both within and between the countries (can be based on value, mass, units, environmental hazard etc). This is part of the competition between the PROs. Also the payment flows between the municipalities and PROs vary between the countries. In Sweden, the municipalities are paid by the PROs in order to collect the WEEE, while in Norway and Denmark this work is supposed to be covered by the municipal waste fees. However, in Norway, the municipalities can be paid a ”compensation” for sorting the WEEE into certain categories. In addition, the competition for access to WEEE between PROs in Norway has resulted in specific payment agreements between PROs and large municipalities, which means that the PROs may pay the municipalities for their WEEE even though their duty is to collect the WEEE free of charge.

According to Norwegian Competition Authority (Konkurransetilsynet, 2015), the municipal ownership of the WEEE at their recycling centers impairs the PROs possibilities to fulfill their collection duties. However, according to the Norwegian EPA (Miljødirektoratet), this is not a problem as long as the PROs are only required to collect their allocated share of the total collected volumes within the PRO system (Frantzen, 2015).

Financial guarantees offered by the PROs

PROs in Denmark, Norway and Sweden have the possibility to fulfill the requirement of financial guarantees, which is done by all PROs. In Denmark PROs have applied for exemption of financial guarantees (as they fulfil certain requirements), which have been approved. Thus in practice neither the PROs nor their connected producers ensure financial guarantees in Denmark. However, producers not registered to a PRO must pay a specific management cost per EEE category calculated by DPA-System as basis for financial guarantees.

PROs in Norway and El-Kretsen in Sweden provide a collective financing solution for financial guarantees, included in their fees. In Norway PROs must have the financial resources to fulfill the obligations of its members for a minimum of six months. El-Kretsen has set aside funds to cover WEEE handling for at least one year of operation. At EÅF every product is individually insured and the financial resources set aside depends on the expected lifetime of each product. According to the webpage of EÅF[9] a major risk in a collective financial solution is that a producer has to take responsibility for someone else´s waste. This risk is eliminated by individually insuring each product.

[9] http://elektronikatervinning.com/producentansvar/ny-producent/

5 Clearinghouse

5.1 Clearinghouse model in Denmark

As mentioned in Chapter 3, DPA-System is a non-profit and non-governmental company with a board consisting of representatives from trade associations; DI Dansk Erhverv, Batteriforeningen, De danske bilimportører, FEHA (Foreningen af Fabrikanter og Importører af Elektriske Husholdningsapparater), VELTEK (VVS og el-tekniske leverandørers brancheforening) and FABA (Foreningen af fabrikanter og importører af elektriske belysningsarmaturer) (DPA-System, 2015b). The role of DPA-System is described in the WEEE Order.

The clearing mechanism, described in DPA-System (2014c), is volume-based and only includes collection of WEEE from private households from municipal collection sites. The producers must take back their proportionate share of WEEE from private households from the municipal collection sites. The proportionate share for each producer is calculated based on the quantities of EEE used by consumer reported to DPA-System and placed on the Danish market in the ten EEE categories. The producer market share per category is calculated as follows:

$$\text{Market share} = \frac{\text{Producer quantity placed on the market}}{\text{Total quantity placed on the market in Denmark}}$$

DPA-System calculates the producer's market shares of WEEE from private households to be collected for each of the six WEEE fractions to which the categories belong according to the WEEE Order. Total expected annual quantity of WEEE is calculated as:

(Quantity of WEEE taken back and registered in the producer register as per 1 April * expected developments in quantities of WEEE for the subsequent year compared to the previous year)

The Environmental Protection Agency determines and informs DPA-System of expected developments in quantities of WEEE, but during recent years the factor has been 1. The clearing is based on a 12 month period and runs from September to September. The producer must collect the total amount of WEEE (the allocated fractions) at the allocated collected points during the whole allocation period, even if the amounts exceed the allocated amounts.

Since future quantities of WEEE are not known, there is need for a post-adjustment mechanism that takes into account the deviation between the market share of WEEE allocated to the producer and the quantity of WEEE taken back by the producer during the previous calendar year. If the producer has collected a higher or lower quantity than the allocation, this is post-adjusted in the preceding allocation period. The adjustments are made based on the following formula:

((Quantity allocated to the producer in the preceding period) – quantity taken back by the producer in the preceding period)

There are also routines for how to include post-adjustment for new producers registering during the course of an allocation period.

Allocation of collection points

When each producer has been allocated a quantity of each fraction to be collected the question remains who is to collect where. To answer this, the expected quantities of each of the six WEEE fractions at every municipal collection point must be estimated, as this is not possible to know in advance. The estimation is based on the expected quantity of WEEE per inhabitant in Denmark to get a kg per capita figure. This figure is then multiplied by the number of inhabitants in each municipality. Once this calculation is made, DPA-System allocates the different areas and associated municipal collection points to the PROs/producers in proportion to their market share of each fraction.

Allocation of the different collection points is done per fraction. This is necessary since producers' market shares typically vary from fraction to fraction. The result may be that several producers or collective schemes are allocated the same collection point, but with responsibility for different fractions. In a few cases this means that there may be five different producers with the responsibility for collecting WEEE at the same collection point.

The allocation of different collection points is not solely decided by DPA-System. Results of discussions with the PROs in recent years have lead to principles used when DPA-System makes the allocation. The allocation principles are presented in Table 4.

Table 4. Allocation principles (DPA-System, 2014c).

Criteria for allocation - priority ranked	Purpose
1. Allocation is done in relation to market shares per fraction. The market share is calculated including adjustments.	Compliance with statutory requirements
2. The smallest allocation unit is a municipality. If the municipality is part of an intermunicipal waste management company this company is the smallest allocation unit. The municipality/waste management company is weighted with the number of inhabitants in the allocation.	Ensures that the municipality/waste management company is serviced by the same collective scheme/-s at all recycling centres
3. In relation to his market share, the producer will be allocated with collection of WEEE and batteries in three geographical areas: • Area 1 Capital Region and Region of Sealand. • Area 2 Region of North Denmark and Region of Central Denmark. • Area 3 Region of Southern Denmark. The producer may be allocated collection in fewer areas if his market share is too small for the allocation to be distributed on allocation units in all three areas.	Ensuring that the producers are allocated with collection of WEEE all over the country, thus offsetting geographical differences in the WEEE.
4. Municipalities are grouped in a way that as far as possible they constitute a coherent geographical area.	Optimization of collection logistics

5. There must be as few collective schemes per municipality as possible. As far as possible, fractions 1 and 2 and fractions 3 and 4, respectively, should be kept together.	Ensuring that the municipality/waste management company is serviced by as few collective schemes as possible at all recycling centres. Optimization of collection logistics.
6. Municipalities are allocated in a way that as few changes as possible from the preceding allocation period are made in terms of collective schemes responsible for the different fractions in the areas.	Ensuring that the municipality has as few changes in producers/collective schemes as possible. Allows for establishment of stable cooperation.

Costs for clearing
DPA-System uses around 860 000 DKK to calculate and communicate the annual allocation for a twelve month period. As it is only producers of EEE used by consumer that are part of the clearing, the producer fees for this EEE are used to cover the work cost of DPA-System (DPASystem, 2015c).

5.2 Clearinghouse model in Norway

The revenues of the five Norwegian PROs come from their members, i.e. the producers. The PROs are obliged to collect the share of the annual collected WEEE volume corresponding to their members' total market share of the EEE put on the market. The collection and reception obligation applies to each product category. In addition, they are obliged to collect WEEE in the national geographical areas corresponding to the areas of which their members put EEE on the market. For each EEE category, the PRO has to fulfil the following requirements during the last 6 months/3 years:

- Cover 75%/90% of all the municipalities represented by their members
- Collect at least 90%/95% of required volume.

Twice a year the PROs need to estimate their obliged collection volumes per category in order to be able to plan their contracts and activities. This estimate is based on own experience with regard to their members' EEE put on market volumes, collection rates, etc. When final data for EEE put on marked and WEEE collected volumes (all data per category group) are available from the WEEE register, the estimates can be replaced by the exact calculated volumes.

Once a year, when the final data for total volumes put on market and total collected volumes are available (around March the year after), the annual post-adjustments according to final obliged collection volumes (per category) volumes are carried out based on the following procedures:

- A PRO that has collected more than required has to collect correspondingly less the next year
- A PRO that has collected less than required has to collect correspondingly more the next year. However, the geographical requirements do not apply for the post-adjusted volume, which means that a PRO can befit from the post-adjustment by collecting more WEEE in the urban areas the following year.

According to the interviews (Norwegian interviews, 2015), the post-adjustment is only followed up by the Norwegian DPA if the PROs have under fulfilled their obligation for the different EEE categories. Thus, they are supervised the next year in order to check whether the extra obligation volume has been collected. On the other hand, if a PRO has over fulfilled their

obligations, this is not followed up at the same way, meaning that the Waste Order's Annex C, Part C, no. 2.08 is not supervised. This means that a PRO, in practice, can over fulfil its obligation over several years without being forced to post-adjust it, and thus hinder other PROs in fulfilling their obligations. On the basis of this lack of a fully following-up system of the post-adjustment requirements, there is a general view among Norwegian PROs that the clearinghouse model in Norway does not work as a real allocation mechanism (ibid).

It should be emphasized that the new draft regulation proposes a revised post-adjustment allocation, but, according to the interviews, this new model do not solve the above mentioned challenges.

According to the Norwegian Competition Authority (Konkurransetilsynet, 2015), both the existing and new drafted WEEE orders are much too complicated to handle, thus representing large establishing barriers. In addition the legislation is accused for encouraging cherry picking and over- and under-fulfilment of collection requirements which may lead to unintended competition incentives. This can be illustrated by one PRO which post-adjusts its under-fulfilment by increased collection in urban areas (cheap collection) the following year, which further, makes it more costly for other PROs to fulfil their requirements. In this game related to the incentives given by the legislation, the different PROs costs and relative competition position are affected (ibid).

5.3 Clearinghouse model in Sweden

When EÅF entered the WEEE market in 2007, El-Kretsen already had established contracts with municipalities (Elretur) in Sweden meaning that El-Kretsen collected WEEE from municipal collection points. As the absolute majority of WEEE is collected through municipal collection points the market share of EÅF did not correspond to the volumes collected by EÅF, which created a need for a financial settlement between El-Kretsen and EÅF. For this reason EÅF and El-Kretsen founded the non-profit organisation "WEEE Clearing i Sverige Ideell förening", which is open for other actors as well (a requirement is that they represents producers and are an approved WEEE set up system). In this clearinghouse the costs for collection and recycling are allocated between EÅF and El-Kretsen. Thus, there are no physical volumes allocated between El-Kretsen and EÅF and the clearinghouse model used may be referred to as financial clearing. Neither is there any decision to take on who should collect from where as it is based on the principle that El-Kretsen collects WEEE from municipal collection poinst and the collection points El-Kretsen has organised directly with their members and other businesses, while EÅF collects WEEE from the collection points EÅF has organised directly with their members and other businesses.

Recently there has been some discussion concerning the clearinghouse model and a new model was developed by the engineering consultancy firm Sweco. This was used for the first time 2014 and will be used onward. The previous model allocated both new and historic waste according to the market share calculated on the basis of what each PRO´s producers had put on the market the same year as the WEEE was collected. In a situation when the proportion of historic waste decreased in the same time as the market share of El-kretsen and EÅF changed it became obvious that the clearing model needed an update so that the responsibility for WEEE was allocated properly.

In the new clearing model one differentiates between historic and new WEEE and includes the expected product lifetime of different product categories, i.e. the time from the product is put on the market until the product has been submitted to recycling. Historic WEEE is allocated according to the market share calculated on the basis of what the PRO´s producers has put on the market the same year as the WEEE was collected. For new WEEE the responsibility arises when the product is put on the market but the costs for the product is taken when the product is expected to become waste, which is determined by expected lifetime. With regard to this the model takes into account how much that has been put on the market every year from August 2005, which corresponds to the total weight in kg for each product distinguished in clearing. The proportion of historical WEEE and new WEEE is determined by the product lifecycle analysis of the different product groups.

The product lifecycle analysis is based on data from El-kretsen´s plant in Arboga. 1.5-2% of El-kretsens´s flow is randomly selected and goes through the Arboga plant where material is sorted up and controlled for the purpose of pricing (to recycling companies) and statistics. For the following product categories, refrigerator and freezer, other white goods, appliances, computers, monitors, multifunction devices, mobile phones, other ICT products, TV, stationary home device, portable home device, expected lifecycle analysis has been developed in which it is estimated how long it will take for a product that is put on the market until it has been submitted for recycling and how long a product “live” before everything becomes waste. Based on the life cycle analysis the proportion of historic and new WEEE has been estimated. E.g. 3% of the collected volumes of for a certain product is new WEEE in 2014, in 2024 40% is new WEEE and in 2032 100% is new WEEE.

El-kretsen and EÅF sit down on a quarterly basis in the “WEEE Clearing i Sverige Ideell förening” and agree on the clearing costs. A final proper clearing is carried out in the beginning of the next year. No authority is involved in the clearing procedure. Instead authorities have said that the WEEE take back system should resolve the issues themselves based on what is written in the Swedish WEEE order. The advantages of this according to interviewees is that PRO are able to provide flexible solutions while the downside is that a lot of responsibility is placed on PRO and that there is no support in cases it arise a locking.

The procedure in the clearing model can be described as follows:

1. El-kretsen and EÅF identify was has been put on the market for each product category. This is calculated by taking the number of products sold multiplied with the weight. The figures are derived from the producer that reports the products put on the market and the weight on a monthly basis.
2. Based on what is put on the market and the estimated models on what is historic and new WEEE the proportion historic and new WEEE that El-kretsen and EÅF should be responsible for is calculated (by Sweco). The responsibility for historic WEEE is based on the principle of what is put on the market today. The responsibility for new WEEE is determined by expected lifetime of different products.
3. El-kretsen and EÅF identifies what has been collected for each product category based on data from recycling companies.

4. Based on the proportion historic and new WEEE and the information on what has actually been collected and the costs associated with the collection the professional service company KPMG calculates the clearing volumes and the clearing costs for each category. Transport costs, pretreatments costs, purchasing costs for cargo carriers and container storage and material value is the factors making up the clearing costs. KPMG is carrying out the calculation, as El-kretsen and EÅF want to have a third party that verifies the numbers. The compensation costs that El-kretsen pay municipalities for the kg WEEE the municipalities are collected are not included in the calculation10 for 2014.
5. El-kretsen and EÅF approve the clearing and the report by KPMG and pay the cost.

According to the PROs it is good to have a model that represent the reality and make a producer responsible for his/her products first when they are collected and not when they are put on the market as a product put on the market today is collected first in some years. One problem with financial clearing is however that EÅF lack some transparency of the costs. Still, a perfect financial clearing with no transparency is probably not desirable as it also means no competition ending up in an oligopoly. Another dilemma that is not directly connected to the clearing model but more to the current structure in which El-kretsen has the contract with municipalities is that EÅF lack control of their WEEE volumes. EÅF do not have the right to the volumes only the financial responsibility of them.

5.4 Comparison of clearinghouse models in Denmark, Norway and Sweden

The WEEE market is regulated and is as such different from other markets. Consequently, in a situation of more than one PRO a clearinghouse mechanism is needed in order to control the market and avoid a situation in which PRO 'cherry pick' the easiest collection, leaving the less easily assessable WEEE uncollected (Khetriwal et al., 2009). The clearinghouse mechanism does look very different in Denmark, Norway and Sweden Table 5 presets the major differences between the countries, which are explained more in detail below.

Table 5. The clearing mechanism in the three countries.

	Denmark	**Norway**	**Sweden**
Organiser of the clearinghouse	DPA-System	Miljødirektoratet/WEEE Register	El-kretsen and EÅF
Who is connected to the clearinghouse	PROs and producers	PROs	PROs
Requirement of entering the clearinghouse	Open for every producer	Only certified PROs	Only certified PROs
Clearing	Volume	Volume	Financial

[10] This is an agreement between El-kretsen and EÅF but may be changed in 2015.

	Denmark	Norway	Sweden
The decision on how to allocate volumes/costs	Based on the market share of what was put on the market the previous year	Based on the market share of what was put on the market the previous year	Historical WEEE based on current market share Cost for new WEEE is taken when the product is expected to become waste
The decision on how to allocate collection points	DPA-System	PRO must collect in all municipalities	El-kretsen collects from municipal collection point

Organiser of the clearinghouse:
In Denmark and Norway an actor outside the WEEE collection is involved in the clearinghouse (i.e. an "outside" actor) whereas in Sweden it is the member of the clearinghouse that monitor and coordinate the clearing themselves. In Denmark it is the non-profit and non-governmental DPA- System that represents the clearinghouse whereas in Norway the WEEE register is carrying out the allocation of the volumes to the different PROs based on the requirements set in the WEEE Order. The involvement of an "outside" actor may be beneficial as it can support the members in case of conflicts and may prevent the risk that members of the clearinghouse set up high obstacles for competition. Still involvement of an outside actor may add to bureaucracy, administration and costs of the system and it may be more difficult to end up in flexible solutions.

Members of the clearinghouse and requirement to enter
Both producers and PRO are members of the Danish clearinghouse whereas in Norway and Sweden only PROs are members. The requirements for entering the clearinghouse is much stricter in Norway and Sweden as it is only open for certified PROs/approved WEEE take back systems whereas in Denmark it is open to every producer.

Clearing
Denmark and Norway have a volume-based clearing whereas Sweden has a financial-based clearing. This means that Denmark and Norway allocate WEEE volumes based on market share and estimated volumes collected whereas in Sweden no physical volumes are allocated; instead collection and recycling costs are allocated between the members of the clearinghouse. In addition only WEEE from private households is included in the clearing in Denmark, whereas in Norway and Sweden both WEEE from private households and WEEE from other than private households is included. A dilemma of having a financial clearing is that the members may lack transparency of the costs figures (one does not operate on the same costs) and that one could question the competition in the system as the members gain from good negotiation and low costs of the other member. If financial clearing is to work perfectly it will probably require that all members in the clearinghouse have the same rights and that they jointly make decisions about investments. This would still mean that the producers might end up in one PRO.

Allocation of volumes/costs
In Denmark and Norway the WEEE volumes to be collected by each member of the clearinghouse are allocated based on the market share of what each member has put on the market and estimated volumes to be collected. The estimation is based on a forecast as it is impossible to known the quantities in advance. In Denmark the allocation is made by DPA-

System whereas in Norway the collection obligation per PRO and category is calculated by the WEEE register based on the requirements given by the Norwegian DPA. A dilemma in the Norwegian system is that PROs may stop collecting WEEE once they have reached their quota. This in turn may lead to a stored volume of negative valued WEEE at the recyclers/transporters due to lack of income from a PRO in order to treat the WEEE. In Denmark the producers must collect WEEE during the whole allocation period, even if the amount exceeds the quota.

As the forecast is never one hundred percent correct there is a need to make a post-adjustment in the beginning of the next period, which results in some subsequent work. In Denmark and Norway the differences between the actual collected amounts and the allocated amounts are taken into consideration when the following year's allocation is made. Still, in Norway the geographical requirements (a PRO has to cover 75%/90% of all the municipalities represented by their members and collect at least 90%/95% of required volumes) put on the current allocation period do not apply for the post-adjusted volume, which means that a PRO can benefit from the post-adjustment by collecting more WEEE in the high density populated municipalities the following year.

In Sweden the actual costs for collection and recycling are allocated to the members on a quarterly basis. As the costs are based on actual figures there is no need for any forecast or post-adjustment. In the clearing model there is a difference between historical and new WEEE. The costs of historical WEEE are allocated based on the market share of what has been put on the market today. The responsibility for new waste arises when the product is put on the market but the cost of the product is covered when the product is expected to become waste (determined based on product lifetime analysis). Some interviewees argue that the Swedish clearing model where there is a difference between new and historical WEEE better meets the recommendations in the WEEE directive. According to the WEEE directive (2012/19/EU) "each producer should be responsible for financing the management of the waste from his own products. The producer should be able to choose to fulfill this obligation either individually or by joining a collective scheme. Each producer should, when placing a product on the market, provide a financial guarantee to prevent costs for the management of WEEE from orphan products to falling on society or the remaining producers. The responsibility for the financing of the management of historical WEEE should be shared by all existing producers through collective scheme to which all producers that exist on the market when the costs occur contribute proportionately". The conclusion of these sentences is according to the interviewees that advocate the Swedish clearing model that the responsibility for financing historical WEEE should be shared proportionately between the producers based on what is put on the market today, whereas the financing of new WEEE should be taken individually when the costs occur. There is, however, interviewees that disagree and interpret the WEEE directive as if the responsibility of new and historical WEEE should be shared based on the market share of what has been put on the market today. Advocates of the Swedish clearing model argue that making a difference between historical and new WEEE results in a more fair game. As an example, a producer that overtakes the majority of the TV market (by e.g. entering with a new TV) today will with the Danish and Norwegian system have the responsibility of the waste from TVs today, although it is not their waste in reality. There is however interviewees that stress that a separation between new and historical WEEE only complicates the situation and that it all evens out in the end.

Allocation of collection points

Denmark is the only country in which the municipal collection points are allocated the members of the clearinghouse. This decision is taken by DPA-System that together with PROs have put up a number of allocation principles. In Norway and Sweden there is no allocation of collection points. PROs in Norway have to cover 75%/90% of all the municipalities represented by their members and collect at least 90%/95% of required volumes during the last 6 month/3 years. Although those rules was put up for a good reason, to minimize the risk that PROs only focus on high-density populated municipalities, it has according to many interviewees resulted in low logistical efficiency as PROs are collecting WEEE in the same municipalities and sometimes at the same collection points. According to Khetriwal et al. (2009) that is why it is important that legislation includes mechanisms for ensuring balanced competition based on environmental performance rather than on financial performance. The situation in which many PROs are competing with the same collection points also means that municipalities need to coordinate with several PROs making it difficult for municipalities to provide a stable consistent solution for the residents (Nordbakker, 2014).

The decision of who is to collect from where is in Sweden decided upon the structure in which El-kretsen are responsible for the collection from municipal collection points. Beside those collection points El-kretsen and EÅF has organized collection points with their members and businesses and are responsible for their "own" collection points. Seeing that the majority of the WEEE goes through the municipal collection points a drawback of the Swedish system is that EÅF do not have the right to the volumes, but the financial responsibility. According to Hicks (2005) one dominant national PRO that is organizing the collection, transport and recycling are however considered by many stakeholders as providing the simplest and most effective route to collecting and recycling WEEE. Thus there may be some advantages with the current structure as well. Producers that support this model identify the additional costs of extra logistics, separate collection containers and point to economic of scale especially in small countries where volumes cannot create a viable market for multiple system.

As the above discussion indicates there are pros and cons of the three clearinghouse systems and there may be some lessons learned from each of them. It is, however, important to remember that "a one-size-fits-all best case solution would not apply in different parts of the world and to different business environments" (Atasu and Wassenhove, 2012). There are a number of factors that will, depending on the characteristics of each country, have varying impact on the operation of PROs and the clearinghouse mechanism. Issues in particular are:

- Distance and geography, with smaller distances reducing costs for transport and logistics.
- Population size and density, where a higher population enables the generation of economic efficiencies and economies of scale.
- Cost of labour, as collection, sorting and treatment are highly labour intensive.
- Length of time in operation as, with time, there are greater opportunities to fine tune the system, negotiate better contracts with suppliers, rationalize overheads and invest in capacity.
- Consumer behaviour, with established PROs owing their success to prevailing consumer recycling behaviour. The level of WEEE recycling awareness in relation to specific product groups is also a key driver of success.

6 Statistics

The WEEE directive includes collection and recovery targets, which are also reflected in the Danish, Norwegian and Swedish legislation. According to the directive each member state (MS) shall ensure that a minimum collection rate is achieved annually. From 2016, the minimum collection rate should be 45%, calculated on the basis of the total weight of WEEE collected expressed as a percentage of the average weight of EEE placed on the market in the three preceding years in each MS. From 2019, the minimum collection rate to be achieved annually shall be 65% of the average weight of EEE placed on the market in the three preceding years in the MS concerned, or alternatively 85% of WEEE generated in the MS. Until 31 December 2015, a separate collection of at least 4 kg WEEE from private households in average per inhabitant per year, or the same amount of weight of WEEE as collected in the MS on average in the three preceding years, shall apply. MS should also ensure that producers meet the minimum recovery targets by category according to the WEEE Directive. The target is divided into two parts, the proportion of the weight of each product category that should be recovered and the proportion of the weight of each product category that should be recycled (ranging from 70-80% for recovery and 50-80% for recycling.

6.1 Collection, recovering and recycling rates in Denmark

6.1.1 EEE put on the market, WEEE collected, recovered and recycled (2013)

DPA-System writes an annual report summarising the WEEE statistics for Denmark the previous year. The producers of EEE, or the PROs on behalf of their member producers, report the quantities of EEE put on the Danish market in kilos to DPA-System. By the amendment of the WEEE Order it is from 2010 not allowed to use conversion factors as average weight, which some PROs used before. Only the actual weight of the EEE should be registrerad (DPA-System, 2015f).

In the Danish WEEE Order it is stated that an auditor must attest the registered quantities of EEE used by consumer if the producer has an annual turnover exceeding DKK 1 million. From reporting year 2015 also EEE intended for professional use is covered by this rule (DPA-System, 2015e). In Table 6 the official statistics for EEE placed on the Danish market, the quantities of WEEE collected and the collection rates for WEEE from private households in 2013 are presented. EEE put on market in 2013 is the total quantity of registered EEE from a total of 1581 producers. 8 percent of the producers reported 0 kg EEE for 2013. The majority of the quantities are EEE used by consumer, around 80 percent of the total amount put on the market (DPA-System, 2014a).

The collection data is generated from the producers' registered collected quantities of WEEE, divided into WEEE from private households and WEEE from other than private households. WEEE from private households is a total of reported quantities collected at municipal collection points, "producers own collection", and WEEE collected through PROs' regional collection points. The quantities from municipal collection points are collected in six fractions, which are translated into the ten product categories in the WEEE directive. The translation is carried out based on an allocation key developed by DPA-System.

Around 95% of the reported amounts of WEEE from private households derive from municipal collection points. The quantities reported as "producers own collection" is a consequence of 15 § in the WEEE Order where it is stated that producers shall report the quantities of WEEE which the producer has taken back and treated, indicating in particular the quantities received by distributors. It is in other words the amounts of WEEE, both from private households and from other than private households that the producer has taken back through distributors.

Table 6. Quantities of EEE put on the market, WEEE collected and collection rates in Denmark 2013 (DPA-System, 2014a).

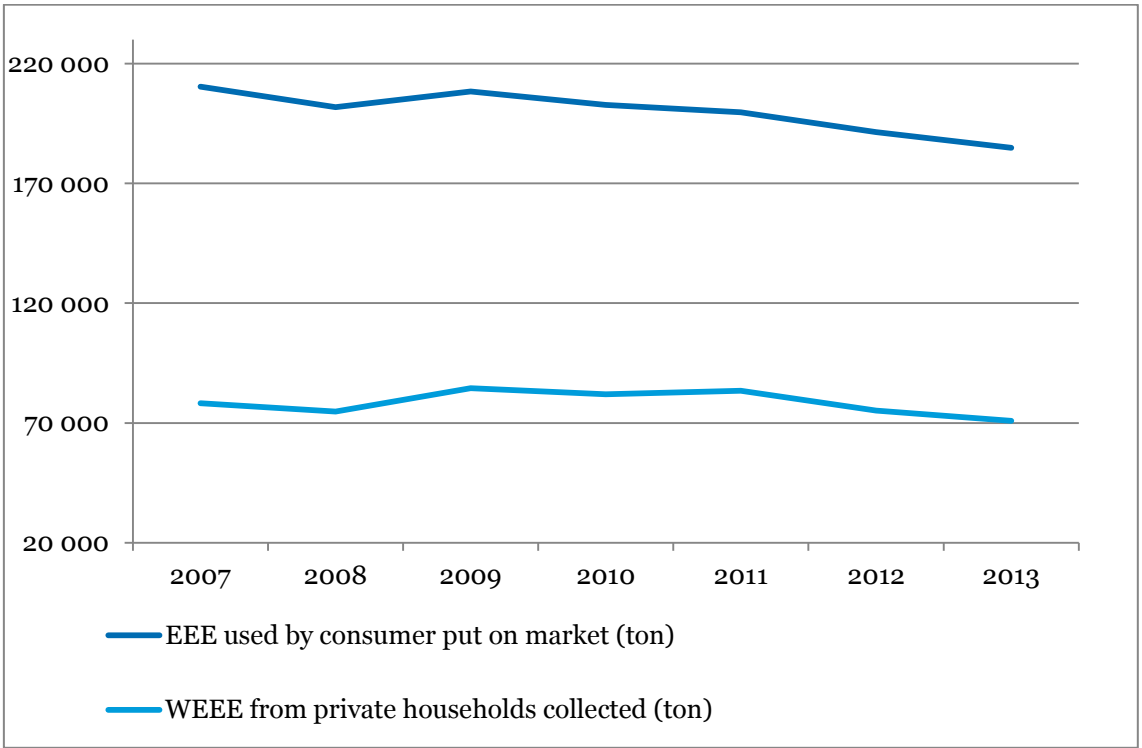
Year 2013	**Quantities put on the market (ton)**		**Quantities collected (ton)**		**Collection rate (%)**
	EEE for use in households	EEE for professional use	WEEE from private households	WEEE from other than private households	(WEEE from private households /EEE used by consumer)
1. Large household appliances	63 172	3 654	32 146	197	51%
2. Small household appliances	13 557	514	4 993	60	37%
3. IT and telecommunications equipment	12 689	7 280	12 162	635	96%
4. Consumer equipment	11 582	922	19 144	107	165%
5a. Lighting equipment – Luminaries11	2 080	1 810	11	9	1%
5b. Lighting equipment - Light sources	1,397	77	682	5	49%
6. Electrical and electronic tools	6 028	2 260	980	51	16%
7. Toys, leisure and sports equipment	3 076	75	213	2	7%
8. Medical devices	130	1 997	48	11	37%
9. Monitoring and control instruments	296	5 421	466	158	157%
10. Automatic dispensers12	-	416	-	1	0%
Total	**114 007**	**24 426**	**70 845**	**1 236**	**62%**

[11] Category 5a: Luminaires used to only be covered for business end-users, but as from 2010 they are also covered for luminaires used in households.
[12] Category 10: As from January 2014 the term "automatiske dispensere" will be used in Danish (used to be 'Salgsautomater'). In future it will also cover household equipment.

The official collection rates vary between 0 percent to over 100 percent, leading to an average collection rate of around 60 percent. WEEE consumer equipment from private households reaches for example a collecting rate of 165 percent. The statistics is for several reasons not complete why the collection rates should be interpreted with precaution.

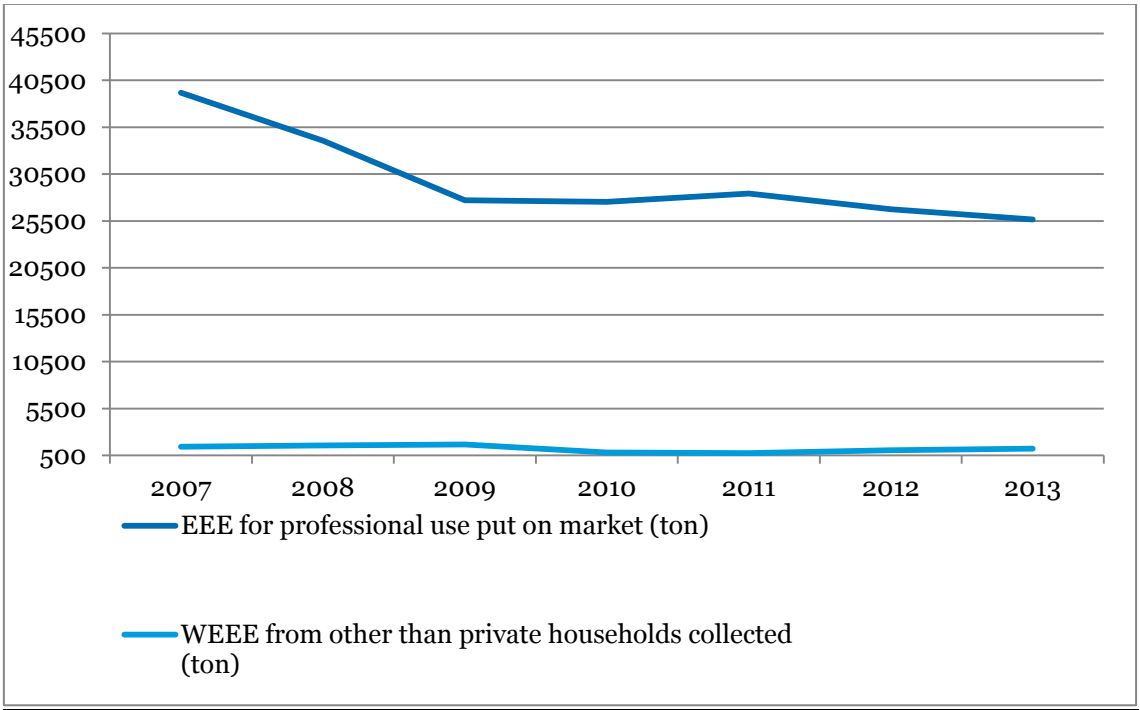
The trend in quantities of EEE used by consumer put on the market and WEEE from private households collected from 2007 and 2013 are presented in Table 7 and for EEE for professional use and WEEE from other than private households in Table 8. The quantities put on market have decreased since 2007, which partly can be explained by the fact that the weight per EEE product has decreased in weight. From 2011 the collected amounts has also decreased, but the gap between quantities put on the market and collected quantities have remained quite stable during the five years presented. The gap between EEE for professional use and collected WEEE from other than private households has decreased during the latest years (Table 8).

Table 7. EEE used by consumer and WEEE from private households collected 2007-2013 in Denmark.



	2007	2008	2009	2010	2011	2012	2013
EEE used by consumer (ton)	132 135	127 012	123 824	120 734	116 116	116 289	114 007
WEEE from private households collected (ton)	78 181	74 749	84 449	81 927	83 496	75 127	70 845
Collection rate (%)	59%	59%	68%	68%	72%	65%	62%

Table 8. EEE for professional use and WEEE from other than private households collected 2007-2013 in Denmark.



	2007	2008	2009	2010	2011	2012	2013
EEE intended for professional use put on market (ton)	37 755	32 483	26 016	26 728	27 664	25 668	24 424
WEEE from other than private households collected (ton)	1 422	1 582	1 684	811	763	1 072	1 236
Collection rate (%)	4%	5%	6%	3%	3%	4%	5%

The fulfilment of recovery and recycling targets for Denmark are presented in Table 9. The underlying data to calculation of recovery rates is solely reported data to DPA-System from producers and PROs. DPA-System assumes that producers and PROs obtain data on treatment from the treatment facilities, but there is no supervision from any authority on the quantities of WEEE reported as treated. To calculate the amount of WEEE recycled and recovered the reported amounts of recycled or recovered WEEE per EEE category are divided by the collected quantities of the same fraction. EEE put on the market is not used as basis for the calculations (DPA-System, 2015d).

The majority of the treated WEEE in 2013, 78 percent, was treated in Denmark. Treatment in Denmark means that the first part of the treatment is carried out in Danish facilities, e.g.

shredding into fractions that are then sold abroad for further processing. The collected quantities of WEEE are not necessarily treated the same year as they have been collected why there is a discrepancy in the collected and treated quantities. According to the official statistics there was no treatment of collected WEEE outside of the EU in 2013 (DPA-System, 2015a).

Table 9. Recovery and recycling targets as well as recovery and recycling rates for Denmark 2013.

Recovery targets				
	Recovered		Recycled	
	Target	Result	Target	Result
1. Large household appliances	80%	90%	75%	81%
2. Small household appliances	70%	90%	50%	83%
3. IT and telecommunications equipment	75%	76%	65%	70%
4. Consumer equipment	75%	96%	65%	92%
5a. Lighting equipment – Luminaries	70%	90%	50%	81%
5b. Lighting equipment - Light sources	80%	98%		97%
6. Electrical and electronic tools	70%	75%	80%	68%
7. Toys, leisure and sports equipment	70%	99%	50%	92%
8. Medical devices		75%		67%
9. Monitoring and control instruments	80%	86%	50%	77%
10. Automatic dispensers	80%	80%	75%	80%

6.1.2 Statistical gaps

There are several factors making the official WEEE statistics incomplete. For example, distributors accepting WEEE from private households shall according to the legislation deliver the quantities to municipal collection points or to regional collection points, but in practice they often sell the WEEE to waste companies. As a result the WEEE is not registered to DPA-System. The treatment facilities report their accepted quantities of WEEE to the national waste register, but this register is not yet synchronised with the WEEE register. DPA-System has noticed an increasing trend of WEEE from private households taking other routes than the municipal collection points (DPA-System, 2015d).

Another gap in the statistics is the fact that producers of EEE for professional use have the right to transfer the responsibility for collection and treatment down in the value chain, if the purchaser of the equipment agrees to take over the responsibility. Generators of WEEE from other than private households are therefore free to contract a waste company who collects and treats the WEEE from other than private households, but the quantities are not reported to DPA-System. DPA-System estimates that there is a significant amount of WEEE from other than private households not covered by the statistics. The statistics for WEEE from private households is more complete than WEEE from other than private households (DPA-System, 2015d).

Another gap is that WEEE from other than private households collected at municipal collection sites are registered as WEEE from private households as differentiation is not possible.

The gap between marketed and collected amounts may partly be explained by stockpiling of WEEE. If the stockpiling was the only explanation of the gap, and the difference between the marketed and collected amounts (in 2013) was divided by 5.6 million inhabitants it would result in an accumulation of WEEE from private households of around 8 kg per person and year. For a family of four it would mean that around 30 kg would accumulate annually, which seems to be an unrealistic figure. A more realistic explanation is incomplete reporting to DPA-System mentioned above (Danish Ministry of Environment, 2012).

6.2 Collection, recovering and recycling rates in Norway

It should be emphasised that the Norwegian data presented in this chapter excludes the additional Norwegian WEEE categories (12-14) in order to make comparisons with Swedish and Danish statistics possible.

6.2.1 EEE put on the market, WEEE collected, recovered and recycled (2013)

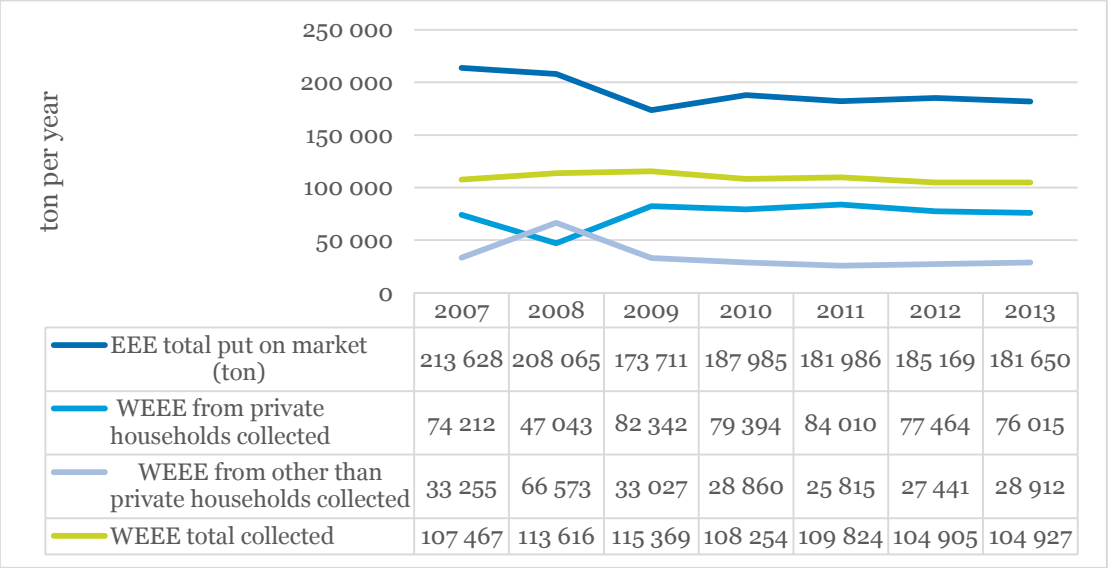
Based on data from the WEEE register, Table 10 shows the total volume of EEE put on market as well as the collected WEEE volumes from private households and from other than private households, respectively. In addition, the collection rates have been calculated.

Table 10. Quantities of EEE put on the market, WEEE collected and collection rates in Norway 2013 (The WEEE register, 2015).

Year 2013	Quantities put on the market (ton)	Quantities collected (ton)		Collection rate (%)
	EEE products total	WEEE from private households	WEEE from other than private households	WEEE total collected/EEE total put on market
1. Large household appliances	73 010	40 963	4 436	62 %
2. Small household appliances	16 454	4 716	719	33 %
3. IT and telecommunications equipment	25 365	8 817	5 337	56 %
4. Consumer equipment	17 234	14 499	1 954	95 %
5. Lighting equipment	24 389	3 348	5 538	36 %
6. Light sources	2 488	236	666	36 %
7. Electrical and electronic tools	12 308	2 570	7 327	80 %
8. Toys, leisure and sports equipment	2 225	547	122	30 %
9. Medical devices	1 013	59	465	52 %
10. Monitoring and control instruments	6 454	254	1 883	33 %
11. Automatic dispensers	710	5	464	66 %
Total	**181 650**	**76 015**	**28 912**	**58 %**

The major collected volume is WEEE from private households, representing 72% of the total collected volume and 14.9 kg per capita. Total collected WEEE represents 20.6 kg per capita.

The trends in quantities put on the market and WEEE collected from 2007 until 2013 are presented in Figure 6.



	2007	2008	2009	2010	2011	2012	2013
EEE total put on market (ton)	213 628	208 065	173 711	187 985	181 986	185 169	181 650
WEEE from private households collected	74 212	47 043	82 342	79 394	84 010	77 464	76 015
WEEE from other than private households collected	33 255	66 573	33 027	28 860	25 815	27 441	28 912
WEEE total collected	107 467	113 616	115 369	108 254	109 824	104 905	104 927

Figure 6. EEE put on market and WEEE collected 2007-2013 in Norway.

As seen in Figure 6, the gap between quantities put on the market and collected quantities have remained quite stable during the five years, with collection rates varying between 50% (2007) and 66% (2009).

The fulfilment of recovery targets for Norway is presented in Table 11.

Table 11. Recovery targets and recovery rates for Norway 2013 (WEEE Register, 2013).

2013	Recovery targets			
	Recovered		Recycled (and reused)	
	Target	Result	Target	Result
1. Large household appliances	80 %	94 %	75 %	79 %
2. Small household appliances	70 %	97 %	50 %	84 %
3. IT and telecommunications equipment	75 %	95 %	65 %	82 %
4. Consumer equipment	75 %	95 %	65 %	80 %
5. Lighting equipment	70 %	95 %	50 %	85 %
6. Light sources		93 %	80 %	91 %
7. Electrical and electronic tools	70 %	94 %	50 %	87 %
8. Toys, leisure and sports equipment	70 %	97 %	50 %	84 %
9. Medical devices		95 %		81 %
10. Monitoring and control instruments	70 %	95 %	50 %	84 %
11. Automatic dispensers	80 %	99 %	75 %	87 %

The data represents the total quantity of WEEE, not separated into WEEE from private households and WEEE from other than private households as separated data is not available.

About 50 percent of the treated WEEE (also including product categories 12-14) was treated in Norway, while 18 percent of the collected WEEE was treated outside the EU in 2013 (The WEEE register, 2013). The treatment country shall represent the country where the final treatment of the WEEE (separated into different parts) takes place.

As shown in the table above, the reuse of EEE is included in the recycling targets and results. In addition, reuse is registered separately per PRO, both in total volume (tons) and number of units per product category. This is published by the WEEE register.

6.2.2 Statistical gaps

Since the Norwegian system for registration of EEE is based on data from the Directorate of Customs and Excise, the put on market data is assumed to be relatively accurate. However, free riders may exist as a result of private EEE import as the minimum limit for exemption of custom today is 350 NOK. This can be eliminated by reducing this limit to 0 NOK (Norwegian interviews).

The separation of WEEE into WEEE from private households and WEEE from other than private households represents an error source, as the different sources may be delivered to the same collection sites. However, as long as the total quantity of WEEE is reported to the register, this is a minor problem. Unserious actors may also cause statistical gaps, if they purchase the valuable WEEE and sell/treat it without incorporating it into the official statistics.

6.3 Collection, recovering and recycling rates in Sweden

6.3.1 EEE put on the market, WEEE collected, recovered and recycled (2013)

The official statistics of EEE placed on the Swedish market are reported by the producer/PRO in kilos, as well as data on WEEE collected and treated. Based on this EPA compiles an annual report summarising the WEEE statistics for Sweden the previous year. Producers connected to El-Kretsen choose if they want to report the quantity put on the market to EPA directly or via El-Kretsen. For the quantity collected, El-Kretsen reports the figures on behalf of their producers. EÅF reports both the quantity put on the market and the quantity collected on behalf of their producers.

Producers of EEE intended for professional use not connected to El-Kretsen or EÅF report all figures themselves. According to interviewees, the put on market data is not completely reliable as there is no standard system for the calculation. Does for example a TV of 25 kg contain batteries and other accessories? There is limited control over how producers estimate the weights. Even though a few kilos do not make a significant difference it does make sense from a statistical point of view. Interviewees stress that it would be useful with guidelines for how the reporting should be done.

17.39 kg WEEE from private households per inhabitant was collected in Sweden in 2013. The figure is high in relation to many other countries but the measure kg/year/inhabitant does not give a complete picture of how well the WEEE system works as the collection rate is a result of what has been put on the market (Nnorom et al., 2008). This is also the reason for why the WEEE Directive 2012/19/EU has changed the measure of collection rate (from 2016) to kilos collected per year divided by the average weight of EEE put on the market in the three preceding years.

In Table 12 the official statistics for EEE placed on the Swedish market, the quantities of WEEE collected and collection rates for WEEE from private households in 2013 are presented. The collection rates do look a little strange in some cases, e.g. the collection rate for consumer equipment is over 200%. One explanation is that there is a time delay; the products collected

today were put on the market several years ago and recent EEE typically weight less than old EEE.

Table 12. Quantities of EEE put on the market, WEEE collected and collection rates in Sweden 2013.

Year 2013	Quantities put on the market (ton)		Quantities collected (ton)		Collection rate (%)
	EEE from consumer	EEE for professional use	WEEE from private households	WEEE from other than private households	(WEEE from private households /EEE used by consumer)
1. Large household appliances	120533	0	84744	0	70.3%
2. Small household appliances	25280	0	5484	0	21.7%
3. IT and telecommunications equipment	23500	11701	23365	7530	99.4%
4. Consumer equipment	22228	0	46371	0	208.6%
5a. Lighting equipment	2833	9024	1080	905	38.1%
5b. Gas discharge	2137	211	2050	218	95.9%
6. Electrical and electronic tools	11639	1670	2252	320	19.3%
7. Toys, leisure and sports equipment	7256	438	705	28	9.7%
8. Medical devices	246	1459	43	370	17.5%
9. Monitoring and control instruments	183	845	116	109	63.4%
10. Automatic dispensers13	13	1472	0	877	0,0%
Total	**215848**	**26820**	**166210**	**10357**	**77.0%**

The trend in quantities of EEE used by consumer put on the market and WEEE from private households collected from 2008[14] to 2013 is presented in **Error! Reference source not ound.** whereas in Table 14 the trend in quantities of EEE intended for professional use and WEEE from other than private households for the same period is shown. As the tables illustrates the gap between EEE used by consumer put on the market and collected WEEE for private households has decreased a little whereas the gap between EEE intended for professional use and WEEE from other than private household has remained quite stable during the five years presented. The collection rate of WEEE from private households is larger than the collection rate of WEEE from other than private households.

[14] 2007 is excluded as those figures are not reliable according to interview with EPA

Table 13: EEE used by consumer and WEEE from private households collected 2008-2013 in Sweden.

	2008	2009	2010	2011	2012	2013
EEE used by consumer put on market (ton)	207982	199021	210457	208459	185990	215848
WEEE from private households collected (ton)	139359	142767	148891	165831	157833	166210
Collection rate (%)	67	72	71	80	85	77

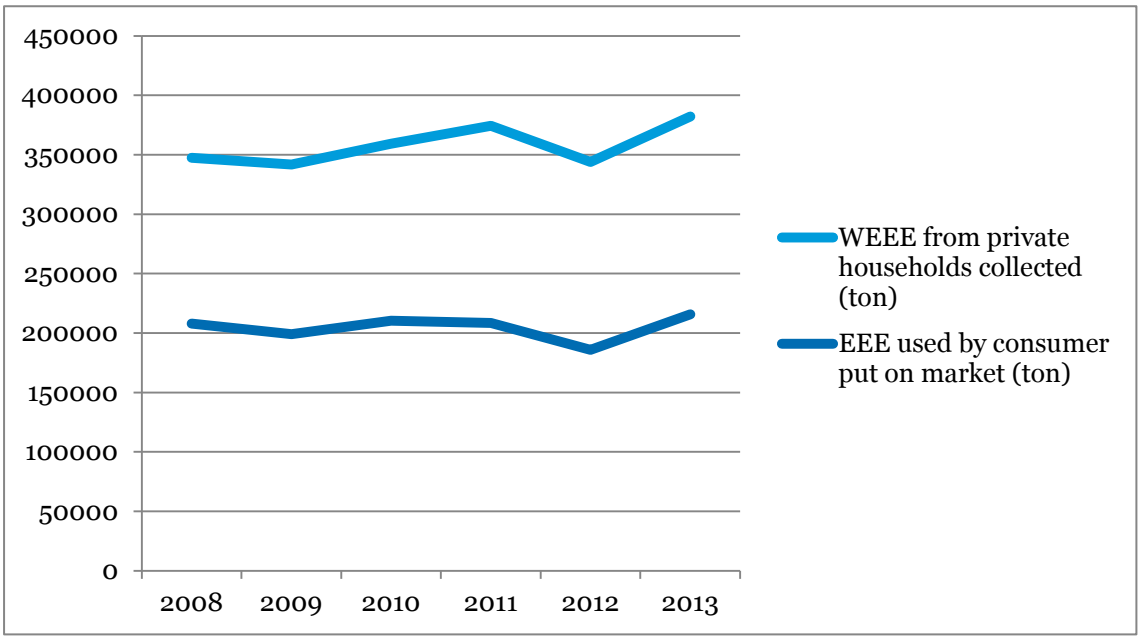
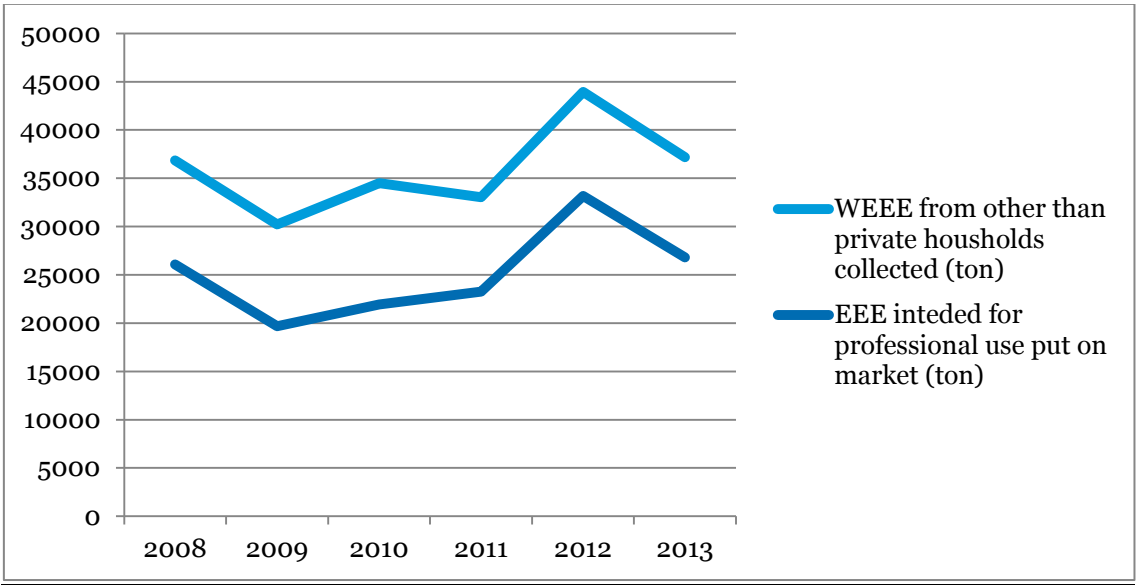


Table 14. EEE intended for professional use and WEEE from other than private households collected 2008-2013 in Sweden.



	2008	2009	2010	2011	2012	2013
EEE intended for professional use put on market (ton)	26079	19686	21945	23272	33171	26820
WEEE from other than private households collected (ton)	10762	10522	12538	9770	10782	10357
Collection rate (%)	41	53	57	42	33	39

The fulfilment of recovery and recycling targets for Sweden 2013 are presented in Table 15 i.e. the target and rates apply to total weight of WEEE (WEEE from private households and WEEE from other than private households). Figures reported by producers/PROs form the basis for the calculation of the recovery and recycling rates made by the EPA. The recovery and recycling rates should be calculated based on the quantities of WEEE recycled or recovered divided by the total quantity of WEEE collected according to the Swedish WEEE order. 'Recovery' refers to material recycling, energy recovery or reuse and 'recycling' refers to material recycling and reuse. Producers/PROs obtain data from recycling companies and give guidance to the recycling companies on how they would like to have it reported.

The recovery and recycling rates typically exceed the targets in the WEEE directive. The rates for some of the categories seem questionable, e.g. recovery and recycling rate for gas discharge is 101% and 165% for automatic dispensers. One explanation could be that underlying data is incorrect. According to EPA (2009), it is not clear for the recycling companies where in the

recycling system the measurement should take place. It is impossible to track recycled material for each product category as the sorting is based on safety and not on the categories according to the WEEE directive.

Table 15. Summary of the recovery targets and results in Sweden for 2013 (EE registret).

	Recovered		Recycled	
	Target	**Result**	**Target**	**Result**
1.Large household appliances	80%	90%	75%	86%
2.Small household appliances	70%	89%	50%	74%
3.IT and telecommunications	75%	93%	65%	84%
4.Consumer equipment	75%	95%	65%	84%
5.Light equipment	70%	89%	50%	78%
51. Gas discharge	80%	101%		101%
6.Electric and electronic tools	70%	80%	80%	66%
7.Toys, leisure and sport equipment	70%	82%	50%	70%
8.Medical devices		96%		89%
9.Monitoring and control instruments	80%	95%	50%	86%
10.Automatic dispensers	80%	165%	75%	165%

6.3.2 Statistical gaps

There are several factors resulting in incomplete official statistics. Other actors than PROs collect WEEE from private households from businesses, and as the actors are not required to report the data to the national register the collected quantities represents a statistical gap. To cope with this dilemma recycling companies and other actors will be required to report collected and recycled quantities of WEEE to EPA according to the Waste order (§54, 54a, 59, 59a).

Another problem is free-riders, i.e. producers that are not registered to EPA. Their volumes are collected, but the put on market data is lacking. This will also be true for products bought online. In addition, some of the EEE put on the market is subject to illegal export to countries outside of the EU. According to EPA (2009):

- it is very likely that there is a leakage of WEEE from Sweden.
- the leakage from collection points to recycling companies could be considered as small. The ERP system Ataio at El-Kretsen makes it possible to follow the flow from the time it was collected at collection points to the point of reception at recycling companies.
- WEEE disappears from municipal collection points.
- there is no knowledge about the fate of the stolen WEEE from collection points.
- there is not sufficient knowledge about possible leakage in other parts of the WEEE system.
- a possible leakage could derive from businesses and authorities. These flows could be relatively large.

6.4 Comparison of collection, recycling and re-used rates in Denmark, Norway and Sweden

Comparison of statistics should be made with precaution, including comparison of collection rates, statistics on EEE put on the market and quantities of treated WEEE.

EEE put on the market
EEE used by consumer put on the market is dominating over EEE intended for professional use in all three countries. EEE used by consumer is representing over 80 percent of the total amount of EEE put on the market in Denmark and over 90 percent in Sweden. In Norway, EEE used by consumer cannot be distinguished in the statistics. However, WEEE from private households represents about 72 percent of the total collected volumes.

The total amount of EEE put on market in the ten categories must be reported according to the respective legislation. Norway stands out as the producers/PROs do not report data to the national register as in Denmark and Sweden. Data is instead retrieved from customs statistics. Private import of EEE is also declared if the amount exceeds 350 NOK. Private import is not at all covered in the Danish and Swedish statistics.

Free-riders exist in all countries, but the statistical gap due to this fact is not possible to quantitatively estimate. Norway is thus assumed to have minor problems with free-riders as the data on EEE put on the Norwegian market is retrieved from customs statistics, making cheating more difficult.

Free-riders place an unfair burden on EEE producers in terms of additional recycling costs and uncompetitive product pricing (Khetriwal et al., 2011). Another source of competition distortion is the deliberate reporting of EEE used by consumer as EEE intended for professional use or simply not reporting the full quantity of goods put on the market (ibid). The EEE put on the market in Denmark and Sweden is subject to limited supervision compared to the Norwegian situation. In addition, quantities of EEE imported by companies for own use is not part of the statistics in Denmark.

Collected amounts of WEEE

According to the official statistics, the collected amounts of WEEE from private households per capita was 12.5 kg in Denmark, 14.9 in Norway and 17.4 kg in Sweden in 2013. It should, however, be emphasized that the Norwegian figure only includes WEEE generated by private households. When including WEEE from other than households the figure is 20.6 kg per capita. The highest amount of WEEE from private households collected is, not surprisingly, represented by the category "Large consumer equipment". The overall collection rate for WEEE from private households lies around 60 percent for both Denmark and Norway, whereas the collection rate in Sweden was almost 80 percent in 2013.

The collected quantities of WEEE all derive from national registers. When comparing collected quantities of WEEE it is important to bear in mind that the reporting requirement is not the same in the three countries. It is moreover important to differ between what should not be reported, and what is not reported despite obligation to do so. For example there is no obligation to report WEEE from other than private households managed on a business-to-business level in none of the countries, and as a consequence the statistics lacks this fact. In Sweden, WEEE from private households from other than households can be collected by other actors than the PROs, and they have no obligation to report collection data to the national register (this is about to be changed). In Table 16 the underlying sources for the official statistics on collected quantities of WEEE are summarised. X means that the flow is reported with relatively good coverage, and (X) means that the flow is reported to a limited extent, which is the case for distributors' collection in Denmark and Sweden. As seen, WEEE from other than private households collected on a business-to-business level is not part of the official statistics. Of the total collected amounts of WEEE from private households over 95% is collected through municipal collection points. Regional collection points managed by PROs only exist in Denmark and Norway.

Table 16. Underlying sources for the collection statistics.

	Denmark	**Norway**	**Sweden**
WEEE from private households collected:			
- from municipal collection points	X	X	X
- by distributors	(X)	X	(X)
- from PROs regional collection points	X	X	-
WEEE from other than private households collected:			
- on a business-to-business level	-	-	-
- by distributors	(X)	X	(X)

Weaknesses in the collection statistics worth mentioning are for example that the collected quantities are not reported as they should, illegal export, and theft or "disappearance" of WEEE at the municipal collection points. Smaller WEEE fractions are also found in mixed waste fractions where it does not belong. The high value of certain WEEE fractions contributes to unofficial routes.

Gap between EEE put on the market and WEEE collected

The gap between EEE put on market and WEEE collected has been rather stable during the latest years in all three countries. The recovery and recycling targets set in the WEEE directive are met for all categories of WEEE in Denmark, Norway and Sweden. The targets are calculated based on the same principles, collected amounts of EEE divided by the recycled or recovered quantities of WEEE for each category. The instruction in the directive that EEE put on the market could be used as denominator is not used in the three countries. The data on treated quantities of WEEE are reported by PROs and gathered from the treatment facilities. The data on recycling and recovery is not subject to any supervision.

As free-riders' quantities of EEE put on the market is not registered, but is part of the collection statistics this might also lead to a gap between quantities put on the market and collected amounts.

WEEE not collected in the official system may end up in the unofficial system through illegal activities, such as theft and selling to third parties (Chancerel, 2010 in Baxter et al., 2015). However, this seems to be less common in the Nordic countries than on the EU level (Toppila, 2009 and Hemström et al., 2012 in Baxter et al., 2015)

7 Environmental Assessment

7.1 Methodology

The environmental assessment was carried out to answer two main questions:

- Which WEEE fractions are most important to recycle from an environmental perspective?
- How large is the environmental impact from transport compared to other environmental impacts from WEEE?

The study is based on Life Cycle Assessment (LCA) methodology. The life cycle of all products comprises several phases, including production, distribution, consumption, and end of life management, as well as the upstream and downstream processes associated with production (e.g., the extraction of raw materials) and disposal (e.g., the collection, processing, hauling, and disposal or recycling) Many WEEE products have a limited lifetime and therefore the majority of the burden occurs during the production phase. Recycling WEEE products diminishes most or all of the inputs needed to manufacture the replacement product from virgin materials. Avoiding these "upstream" processes significantly reduces energy usage, associated greenhouse gas (GHG) emissions, and other pollutant emissions as well. The LCA model is used to quantify the environmental impacts of material production for the product categories 1, 2, 3, 4, 5 and 7 of the WEEE directive. The model does not include the part production and assembly processes needed to produce EEE products, and as such gives a moderate estimation of the environmental impacts. The material content for each category is based on analysis of a number of characteristic products, as presented in the WRAP study (Haig et. al. 2012). As an exception, category 1 is represented by a weighted average of one refrigerator, one washing machine and one dishwasher based on a study from MIT (Boustani et.al. 2010). A summary of material composition per category is shown in the table below.

Table 17. Material content of WEEE categories in % (w/w) based on Haig et. al. 2012.

Material	Large household	Small household	IT & tele-communi-cations	Consumer equipment	Electrical and electronic tools	Toys, leisure & sports equipment
Fe	2.46	40.31	42.31	33.9	29.14	9.99
Plastic	23.72	36.68	27.53	36.42	48.03	69.82
Al	2.55	14.01	19.81	12.14	9.01	1.86
Cu	2.38	6.92	8.92	6.74	4.9	2.13
Glass	1.46		0.32	0.04		0.06
Ni		0.01	0.04	0.03		0.01
Ag			0.01	0.01		
Cr			0.02			
Sn		0.03	0.48	0.57		0.27
Zn	0.01	0.01				

Material	Large household	Small household	IT & tele-communi-cations	Consumer equipment	Electrical and electronic tools	Toys, leisure & sports equipment
Ba		0.01				
Ca*		0.02		0.02	0.01	0.01
Sr		0.24				
Other (steel)	57.06	1.76	0.55	10.14	8.9	15.85
Paper	0.56					
Rubber	0.64					
Bitumen	4.70					
Wood	1.45					
Gravel	3.13					

**Ca could not be modeled due to lack of data.*

The environmental impacts studied were Global Warming Potential (GWP) in a 100 year perspective, primary energy, abiotic resource depletion, human and freshwater toxicity and Photochemical Ozone creation potential (POCP). The impact assessment model CML2001 (CML 2013) was used for calculation of impacts. The primary energy needed to produce the materials in each category was also calculated.

7.2 Environmental impacts of material production for EEE products

The diagrams below present the environmental impact of producing the materials required to construct the EEE products. All results are presented per kg of the respective WEEE categories.

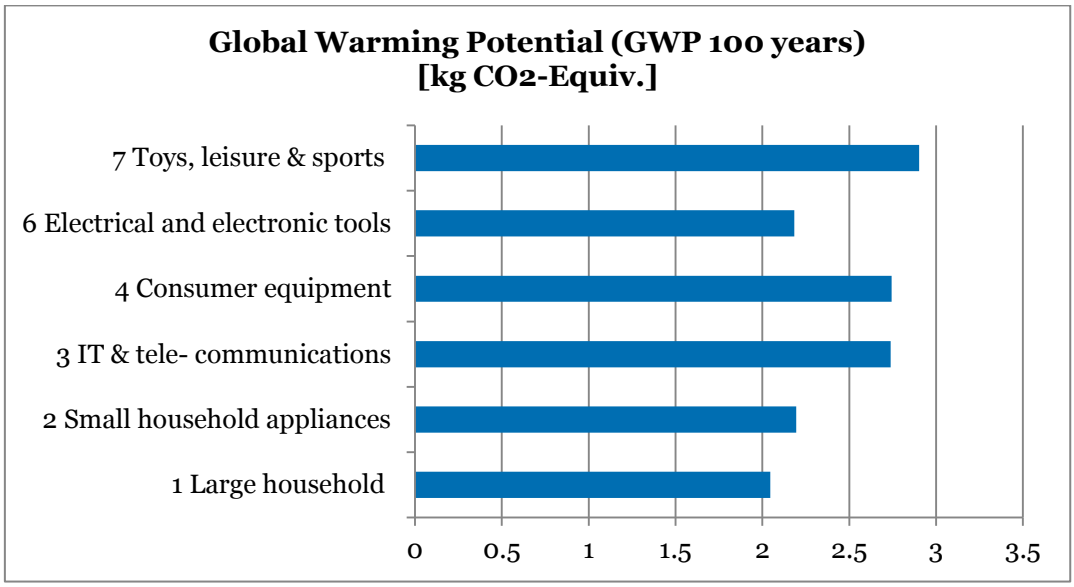


Figure 7. Potential climate impact from EEE material production per category.

The climate impacts of producing materials for EEE products differ between two and three kg CO2-equivalents per kg of the respective fractions. Toys, leisure and sports equipment has the highest impact, almost exclusively due to the high content of ABS plastics, a material produced from oil and that is energy intensive to produce. For EEE category 3 and 4, ABS is also a main contributer to the impact, together with metals like aluminium, copper and steel.

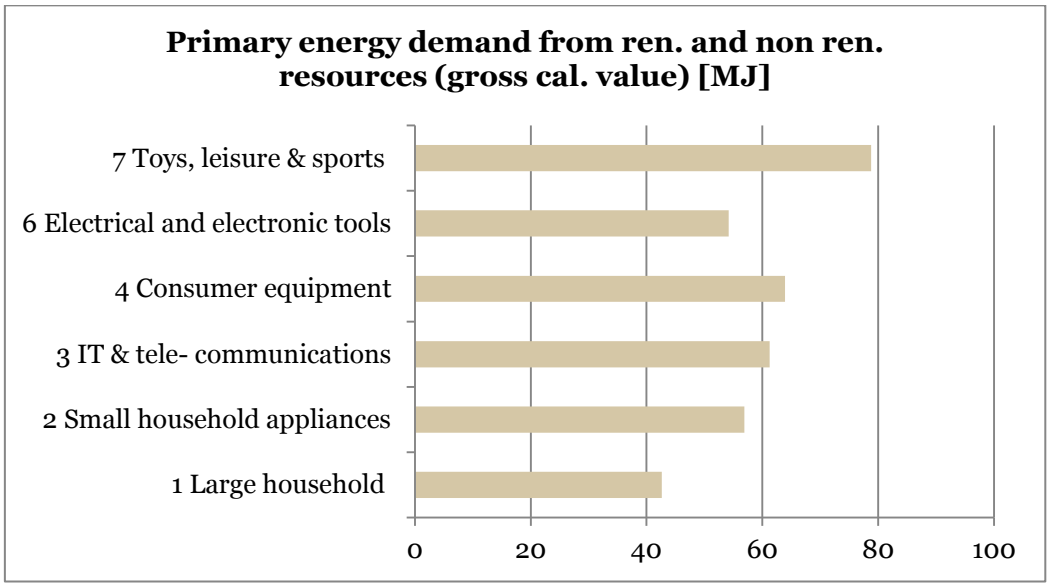


Figure 8. Primary energy demand for material production of EEE products.

The primary energy demand of the different categories follows the same pattern as the climate impact. Again, the Toys, leisure and sports category stands out, due to the high content of energy intensive ABS plastic.

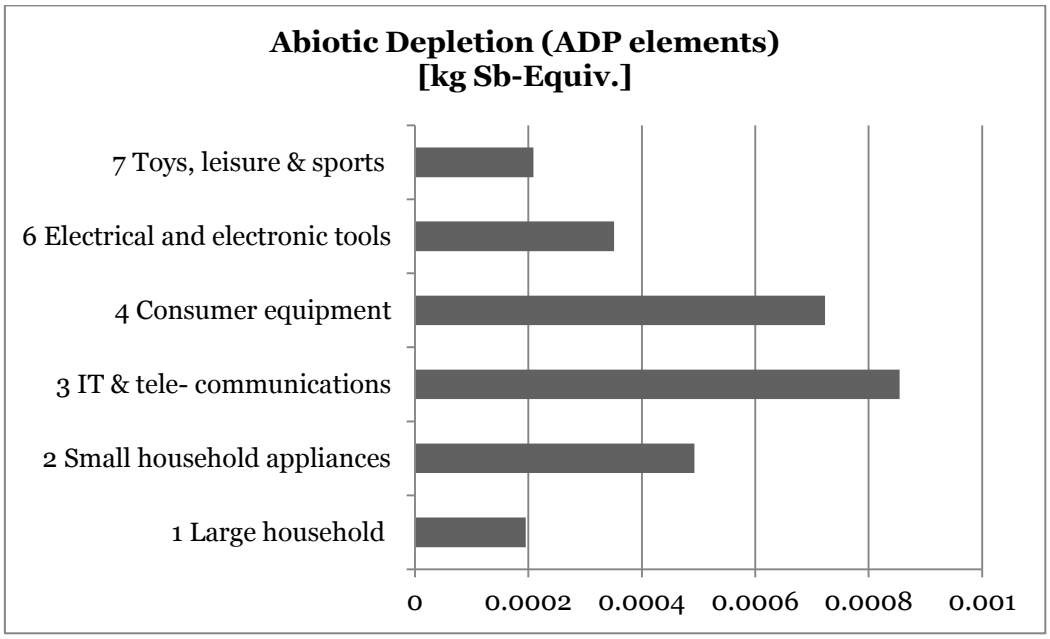


Figure 9. Abiotic depletion potential for material production of EEE products.

The categories 3 and 4 contain silver, and also a relatively high amount of copper. These materials are not common in high concentrations in nature, and are therefore more "scarce" and difficult to produce. This is reflected by the ADP impact category. A short description of this impact category is found in **Error! Reference source not found.**

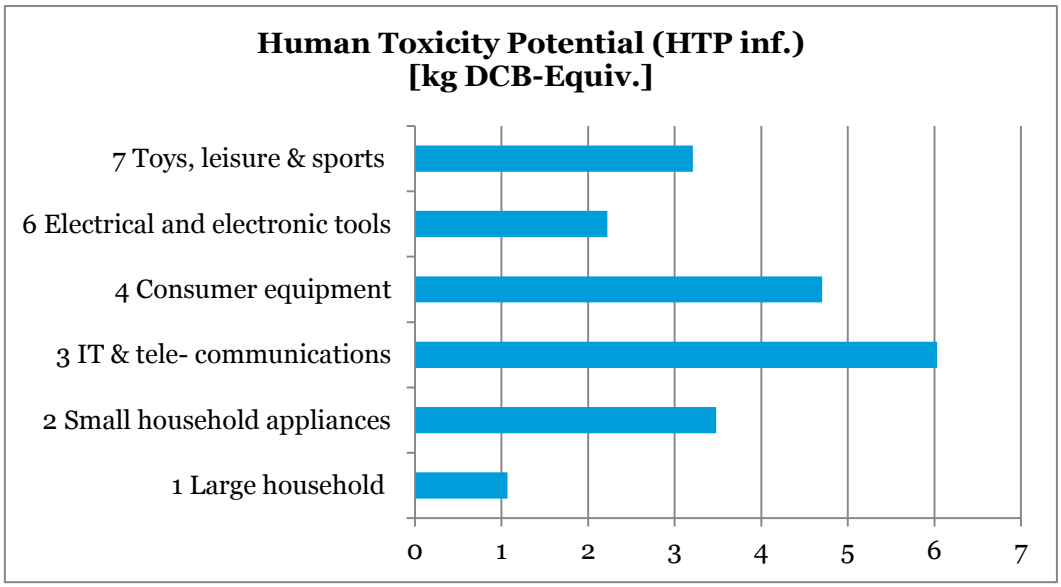


Figure 10. Human toxicity potential of EEE material production per category.

Aluminium production causes most of the human toxicity related impacts, followed by ABS plastics. EEE categories 3 and 4 contain 19% and 12% aluminium respectively, and a large

portion of the plastic in category 3 is ABS. This is the reason for their high impact compared to other EEE categories.

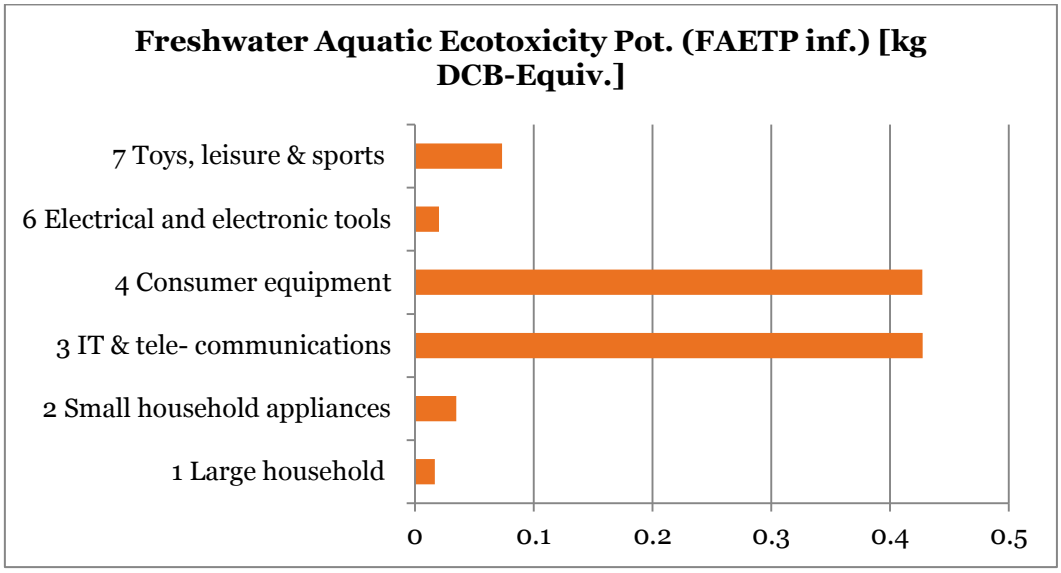


Figure 11. Freshwater toxicity potential for EEE materials production per category.

The results show high impacts for category 3 and 4. The silver content in these categories is responsible for most toxic impacts to freshwater.

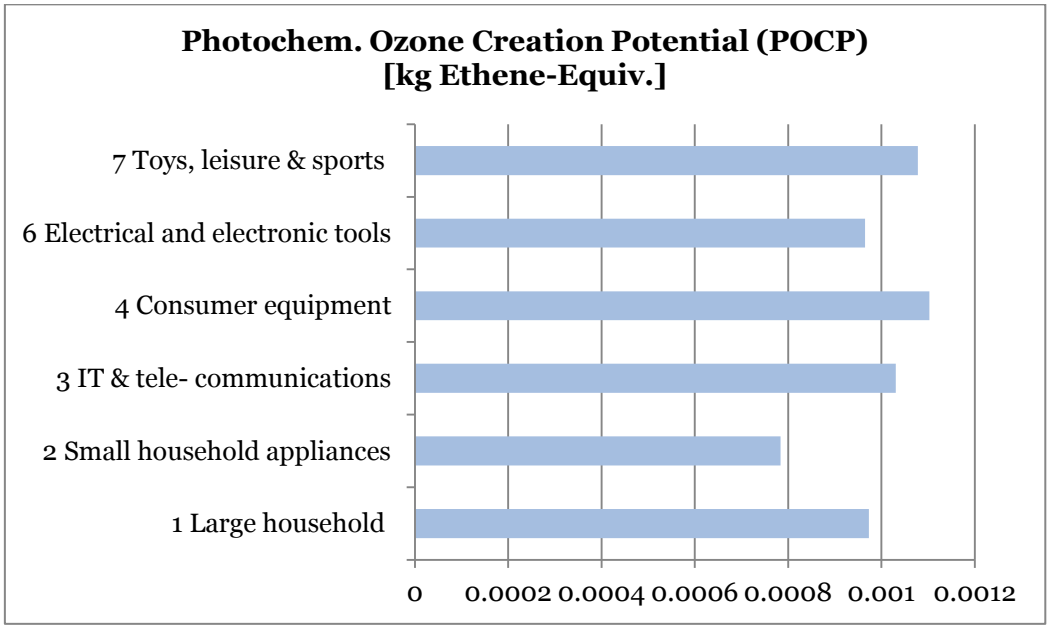


Figure 12. Photochemical Ozone creation potential of EEE materials production per category.

The consumer equipment category has the highest POC potential, followed by toys, leisure & sports equipment. This is due to the content of ABS, steel and copper.

7.3 WEEE fractions of importance to recycle

As seen above, different EEE categories perform differently depending on the type of environmental impact that is studied. Climate impact is given more attention in society today, since is a global impact and has been explained to the public. Impacts like toxicity and POCP are more local, which should be taken into account when interpreting results. CFCs in old refrigerators and freezers are harmful to the ozone layer, which makes them important to handle in a correct way during pre-treatment and recycling. However, this impact was left out of the scope of this study.

From an efficiency point of view, the fractions of most importance to recycle are the ones that contain material that is "costly" to produce from virgin resources. Scarce materials (materials with a high ADP) and materials that require a lot of energy for production (like virgin aluminium) should be given extra attention. The best option from an environmental standpoint is to re-use EEE products for as long as possible before they become waste. This can be achieved through repair and/or upgrading of software, often called remanufacturing, which is the core business of many companies (see for example www.rdc.co.uk).

In this study, both consumer equipment and IT & telecommunication equipment have relatively high impact in all of the environmental impact categories. These are also more complex products containing many different valuable metals. Although it is important to recycle all WEEE categories, consumer equipment and IT & telecommunication equipment could be given priority due to their complex material structure and content of valuable, scarce metals.

7.4 Transport impacts compared to impact from material production

In addition to the material breakdown assessment, we looked at the potential climate impact of transportation connected to collection of WEEE in the recycling systems. Below is a comparison of the global warming potential related to material production and transportation of one kg of cargo on a diesel truck (Euro 3, 17,3 ton payload) for 1000km, with a filling rate of 100% and 50% respectively.

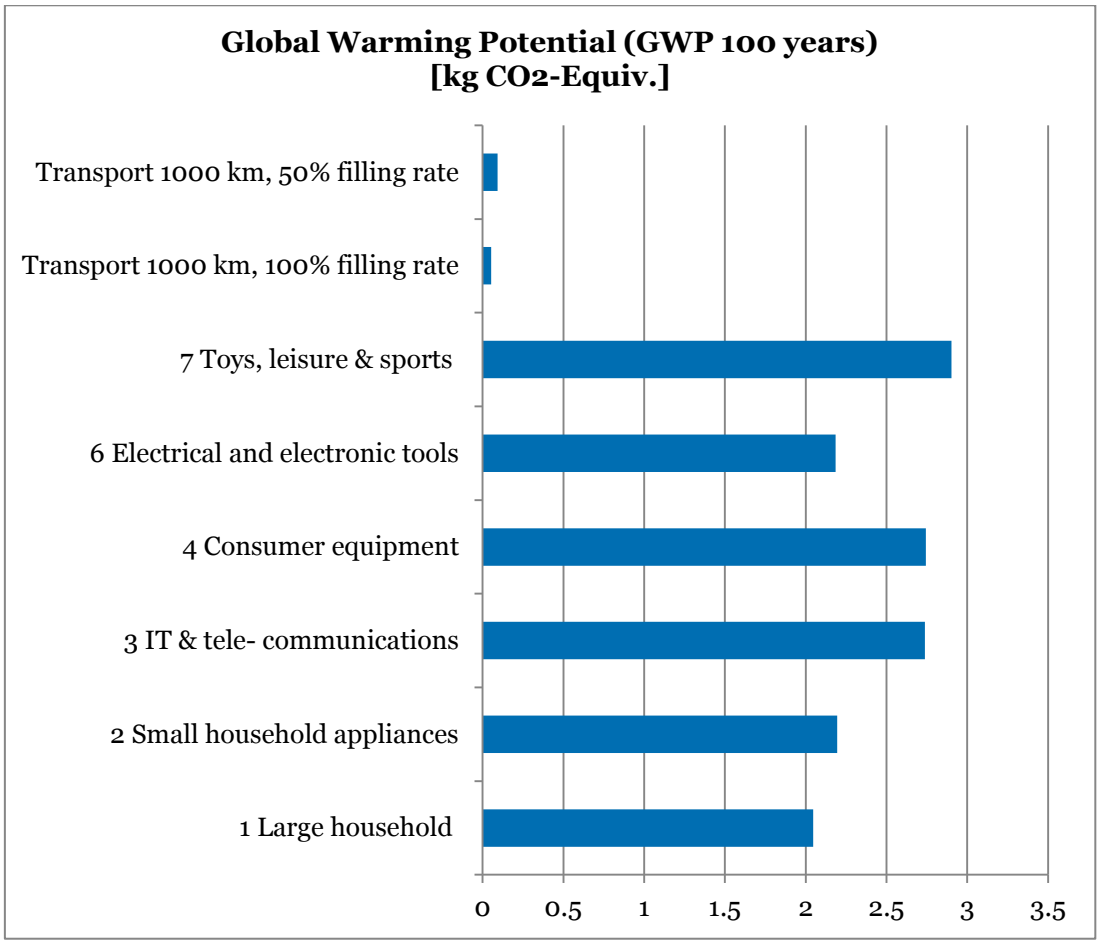


Figure 13. Potential climate impact from material production of one kg of the respective EEE fractions, compared to 1000 km transport of one kg WEEE (50 and 100% filling rate respectively).

According to Elkretsen (personal communication with Lars Ellingsson) the typical vehicle for collecting WEEE in the Swedish system is a EURO 5 Truck-trailer, and the maximum filling rate is based on volume rather than weight for all categories in this study. When collecting mixed electronic waste, the truck can carry on average 15,4 tons, and when collecting large household equipment only 12 tons can be loaded due to the bulky products. Below is a diagram comparing the climate impact of material production and transport 1000 km + 1000 km return of one full truck carrying mixed WEEE (estimated as equivalent to the category IT & telecommunications equipment) and large household equipment respectively.

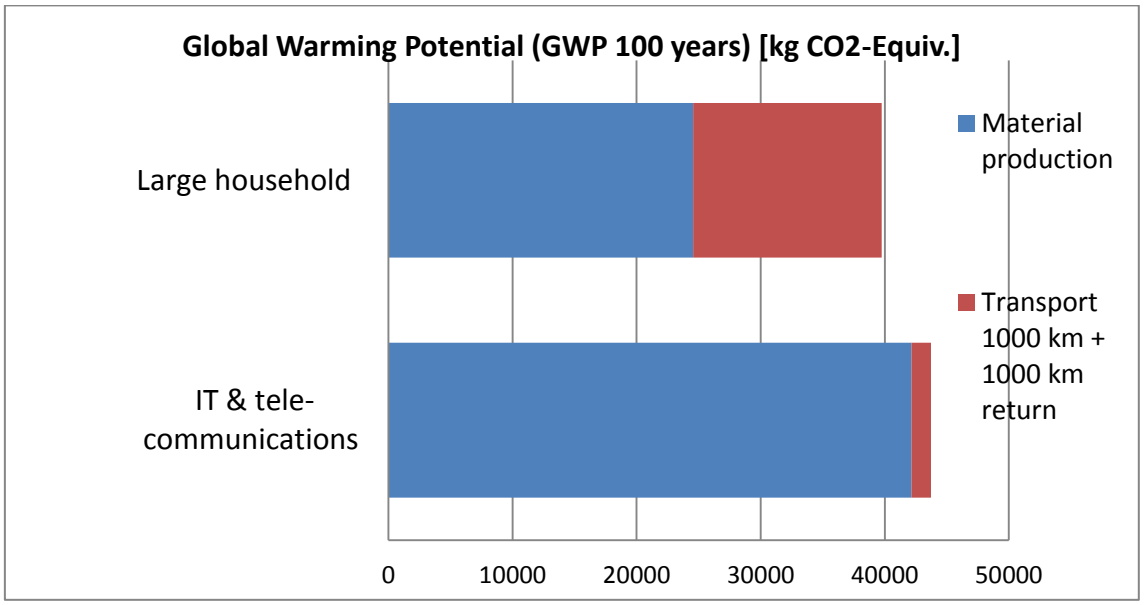


Figure 14. Comparison of climate impact from material production and transport (2000 km) of one typical truckload of WEEE for two categories; Large household equipment and IT & telecommunications equipment.

The simple conclusion to be drawn from this example is that you can transport WEEE a long distance before the climate impact comes close to the impact from material production. Transportation of WEEE should of course be made as efficient as possible, but is not the main issue from an environmental standpoint. As transport is often quite costly, there are economic incentives for efficiency that drive improvements in route planning.

8 Observations and suggestions

Based on the analysis in previous chapters recommendations for how to design and improve an efficient, fair and feasible WEEE system are given. The project has identified advantages and disadvantages with the WEEE system setup in Denmark, Norway and Sweden, and the possibilities to learn from each other are obvious. It is however important to remember that different conditions apply in the three countries, making a "one fits all" system unrealistic.

8.1 Legislation

When discussing the WEEE legislation in Denmark, Norway and Sweden it is important to bear in mind that the new WEEE Directive (Directive 2012) is not yet implemented in Norway, which sometimes complicates the discussions.

No incentive for waste prevention, or design for re-use and recycling
A general observation when studying the respective WEEE orders is that there are no apparent incentives to contribute to sustainable production and consumption of EEE, i.e. by prevention of WEEE, in any of them. This is the main purpose of the WEEE directive. The legislation's impact on product design and prevention of waste seems limited, which is complicated by the fact that the production of EEE primarily takes place abroad. A producer actively working with product design contributing to sustainable production and consumption of EEE is not favored in the WEEE-system in any way. The lack of influence on product design and consumption behaviour in the current WEEE-systems has been raised several times during the project, and it is apparent that the actors in the WEEE-system regard this issue as a serious disadvantage of the implementation of the WEEE Directive.

Detailed legislation seems preferable – the actors' roles should be clear
The level of detail is much higher in the Danish and Norwegian WEEE orders compared to the Swedish counterpart. The actors' roles and responsibilities are more clearly defined, which is seen as positive according to the actors contacted in the project. The risk of jeopardising the flexibility in the systems has not been raised. In addition, more resources in terms of personnel available for guidance and support in interpreting the legislations are allocated to WEEE issues in Denmark and Norway compared to Sweden. The Swedish actors call for more guidance and support, as well as clarifications in how the current legislation should be interpreted.

Is the current WEEE legislation out of date?
The basis in the WEEE directive and the national WEEE legislations is that WEEE comes with negative value meaning that the actors collecting the WEEE pay to have the fractions treated, in addition to the collection costs. This would mean that there are no market incentives to collect and treat WEEE why producer responsibility is needed to make it happen. Today the situation has changed as many WEEE fractions have positive values due to higher demand for secondary raw material sources. This means that the collected WEEE fractions have a positive value and are sold to further treatment, which sometimes also cover the transport costs and result in a net profit for the PROs.

Arguments could be raised that the need for producer responsibility is minimised as there are market incentives for the collection and treatment of WEEE anyway. With strict requirements and improved supervision on the treatment of WEEE the market could be more open to anyone willing to collect WEEE fractions, at least the WEEE fractions with a positive value. As an

interviewee mentioned “it is not about cost allocation, but about profit allocation”. Producer responsibility would still be needed for WEEE of negative value, such as light sources. The challenge with such a change is thus that the material values can move from positive to negative values and vice versa very rapidly. Interviewed actors remember the financial crisis in 2008-2009 when all WEEE fractions all of a sudden got a negative value. A change in legislation would therefore require flexibility to adapt to market changes.

Who owns the WEEE?
An issue getting more and more attention, especially since several WEEE fractions have positive values, is the question of who the owner of the WEEE really is. Is it the municipalities? The PRO/producers? In the WEEE legislations this is not clearly defined, and becomes even more important as reuse of EEE at municipal recycling centers grows in popularity.

Another question on the same topic is whether municipalities should get compensation for their WEEE collection or not. Municipalities in Sweden are currently compensated for their collection whereas in Denmark and Norway the costs associated with collection are covered by municipal waste fees. One could argue that without compensation from producers, municipalities have no or limited incentives to offer collection systems of higher availability, such as kerbside collection. The service level for consumers could be vital in order to collect a higher share of the generated WEEE in the dedicated collection and recycling systems. The current legislation gives limited guidance on the “sufficient” level of availability for consumers in municipalities. An example of the opposite is found in the Swedish end-of-life vehicle legislation, which states that consumers should have the possibility to hand in discarded vehicles within 50 km or within their municipality.

Norway is at the forefront when it comes to reuse of EEE
According to the WEEE Order in Norway, reused products have to function according to their original purpose (not be destroyed, thus representing waste). The PROs are required to have a standard procedure implemented in order to test whether or not the EEE product can be regarded as a functional product of which is supervised by the EPA. The amount of reused EEE products are withdrawn from the overall collection requirement, thus representing an incentive for increased reuse.

8.2 Implementation and clearing

As the WEEE market is a regulated market it is important to ensure that regulations exist also for the allocation of WEEE collection. This prevents cherry picking of the easiest collection leaving the less accessible WEEE uncollected. It also prevents single players from dominating the market and “levels the playing field”. Thus, the clearing mechanism is of high importance in a WEEE system characterised by a competitive market with multiple parties (e.g. PROs, producers, waste organisation) providing services.

An interesting question is what the clearinghouse should regulate. Is it only a question of allocation of volumes or should the collection points be allocated as well? For the clearing mechanism to function in a satisfactory manner it needs to be as fair as possible. We have identified different factors in the three countries that are important to design a fair and efficient system.

Who should collect where? Denmark acts as an example
In the Danish WEEE system both WEEE quantities and geographical location (municipal collection points) are allocated to each producer/PRO. Provided that the actors in the WEEE system find the allocation principles fair, we believe that allocation of collection points should be included in the clearing mechanism. Not only does it minimise the risk of cherry picking or that some collection points are not prioritised, but it also ensures stable logistics.

It could be argued that it is easier to have allocation of collection points in a country like Denmark as the distances are shorter. If such a model was implemented in Sweden and Norway it would need to include measures to compensate for injustices in distance and density. Allocation of collection points would also require a third party to ensure that the allocation is made in an objective way. To gain acceptance the allocation principles could be set up in dialogue with the actors involved, again looking at Denmark as an example. Other issues to consider are the distance to pretreatment centers in the system and the possibilities for PROs to work on a long-term basis with transporters and recycling companies and not have to change collection points too often.

Transport efficiency versus competition
There are certain things (such as PRO members, transport and recycling services) that should be exposed to competition in the WEEE system in order to reduce the costs and increase the service level. However, we do not believe that collection points should be part of the competition as in the Norwegian WEEE-system. In Norway the strong competition, particularly in urban areas, has resulted in several drawbacks in terms of logistical efficiency, costs and service. From a municipal point of view the situation is not ideal as they need to coordinate the collection with several PROs making it difficult to provide a stable and consistent solution for their residents. In Sweden the situation is quite the opposite as one PRO has contracts with all municipalities and there are no additional costs for extra logistics. This is seen as a type of monopoly by some actors, since the allocation of collection points has nothing to do with the PROs market shares and both PROs gain from good clearing negotiations. The ordering and route planning system used in Sweden is also a main reason for the high transport efficiency.

Easy for the consumer
According to the environmental analysis, the impact from transport related to collection of WEEE is of minor importance compared to the recycling benefit. The main priority from an environmental point of view is to collect a higher share of the generated WEEE in the dedicated recycling systems. An increased number of collection points, by collection in stores, could potentially make it easier for the consumer to submit WEEE for collection. However, according to the statistics, the collected volumes (per capita) are not higher in Norway despite the high number of collection points. This implies that there are other aspects that should be taken into count when discussing how to increase the collected volumes.

What factors to take into account to create a fair system?
A clearinghouse model is typically assumed to increase the fairness and the satisfaction of PROs, increase the availability of collection points, reduce costs and show more flexibility. This does however require a good setup of the system in which there are principles for the pre allocation and post adjustment of collection responsibilities. The countries are using different principles for the collection responsibilities, some better than others. In Denmark and Norway the allocation of volumes is based on what each member has put on the market and estimated volumes to be collected, which is a rather common way of allocating volumes in a clearinghouse.

A dilemma in the Norwegian system, however, is that PROs may stop collecting once they have reach their quota. This in turn may lead to a stored volume of negative valued WEEE at the recyclers/transporters.

Historic and new volumes
In Sweden a difference is made between historic and new waste. The costs of historic waste are allocated based on the market share of what is put on the market today. The responsibility for new waste arises when the product is put on the market, but the cost arises when the product is expected to become waste (determined based on product lifetime analysis). Advocates of the Swedish clearing model argue that making a difference between historic and new waste results in a more fair game, since costs for collection and treatment may differ between historic and new products. Without this separation, producers are required to take responsibility for WEEE as soon as they enter the market, before "their own products" become waste. It could however also be argued that we do not know anything about the markets of the future, and it is better to take the costs today. Some interviewees argue that separation of new and historic waste is a theoretical discussion that only complicates that situation.

The opinions differ and it is difficult to give any suggestions for best practice regarding new and historic waste. If market shares change drastically it may be fairer to make a difference between historic and new waste. If the aim is to ensure individual responsibility for specific products it could be more fair to have a financing model based on future costs, although this is difficult. Authorities need to be clear about the financing models for WEEE in the directives. This is not clear today and opens up for misunderstandings.

Allocation procedure
The allocation of volumes is based on a forecast and is as such never completely accurate. This creates a need for post adjustment in the beginning of the next period. A lesson learnt from the Norwegian system is that over achievers should not be able to benefit in the post adjustment of the next periods. It is also important to have as small differences as possible between what has been collected and what should be collected, which is achieved by more frequent adjustment.

An interesting potential is to combine financial clearing with volume based clearing. It could be interesting to investigate the possibilities of using financial compensation on top of the clearing to end up in a more fair allocation that takes e.g. geography and density into account. Another potential of financial clearing is to use it for post adjustment instead of adjusting physical volumes. Still, as members of the clearinghouse do not operate on the same costs, volumes may be better for compensation of injustices and for under and over fulfilment of the obligations at the end of the periods.

8.3 Statistics

Insufficient supervision of WEEE treatment statistics
Data used for calculating the national recovery and recycling rates are reported to the national WEEE registers by the producers and PROs. The producers and PROs receive data from their contracted sorting and recycling facilities, but it is unknown whether the facilities use the same basis for calculation. The data is not subject to any continuous supervision why discrepancies might exist. Weaknesses and differences in reporting routines are also important to consider when comparing recycling and recovery statistics with other countries reporting to Eurostat, not only Nordic countries.

Norwegian data on EEE put on market is the most reliable
The statistics on EEE put on the market in Norway is retrieved from customs statistics on a monthly level, as opposed to the Danish and Swedish data that relies on PROs' or producers' reporting to the national registers. Speculatively, the number of free-riders is assumed to be lower in Norway compared to Denmark and Sweden as the possibility to cheat is limited. This hypothesis is strengthened when looking at the number of producers registered to the national registers. In Norway there are nearly 5000 producers registered, whereas in Denmark and Sweden the numbers are around 1500-2000. This might be explained by the fact that companies importing EEE for own use are exempted from reporting into the national WEEE register in Denmark. According to actors in the Danish WEEE system the control of the reporting into the national register is weak.

Comparison of WEEE statistics should be made with caution
It is tempting to compare collection and recycling rates as well as data on EEE put on the market and quantities of collected and treated WEEE between Denmark, Norway and Sweden. However, this is not recommended due to the fact that the underlying data differs in the three countries. This challenge is not exclusive for WEEE, but typical also for comparison of other waste statistics. If comparisons are made it is important to bear in mind, and to communicate that the reporting requirements are not the same in the three countries. It is also important to differ between what should not be reported, and what is not reported despite reporting obligations.

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Appendix 1: Description of LCA impact categories

Abiotic Depletion Potential (elements)
"Abiotic resources" are natural resources, including energy resources, such as iron ore, crude oil which are regarded as non-living. Abiotic resource depletion is the decrease of availability of the total reserve of potential functions of these resources (CML 2002).

Global warming potential
Global warming is considered as a global effect. Global warming - or the "greenhouse effect" - is the effect of increasing temperature in the lower atmosphere. The lower atmosphere is normally heated by incoming radiation from the outer atmosphere (from the sun). A part of the radiation is normally reflected from the surface of the earth (land or oceans). The content of carbon dioxide (CO_2) and other "greenhouse" gasses (e.g. methane (CH_4), nitrogen dioxide (NO_2), chlorofluorocarbons etc.) in the atmosphere reflect the infrared (IR)-radiation, resulting in the greenhouse effect i.e. an increase of temperature in the lower atmosphere to a level above normal.

Photochemical Ozone Creation Potential (POCP)
This category describes the impact from creation of ground level ozone. Tropospheric ozone, or ground level ozone, has been recognised as an important environmental impact on the regional scale. At high concentrations it is hazardous to human health, but already at lower concentrations it causes damage to the vegetation. Ozone is a trans-boundary pollutant, and it can be produced or consumed by other pollutants during transport over long ranges. POCP is generally presented as a relative value where the amount of ozone produced from a certain VOC is divided by the amount of ozone produced from an equally large emission of ethane. Ethene has been chosen as a reference gas as it is one of the most potent ozone precursors of all VOCs.

Toxicity impact
Toxicity is a complicated impact category, since there is no coherent framework for charachterising the toxicological impact of pollutants. The category includes very many substances such as organic solvents, heavy metals and pesticides that may cause many different types of impacts. Toxicity is therefore often divided into human toxicity and ecotoxicity. Ecotoxicity can then be further divided into aquatic (marine and freshwater) and terrestrial toxicity depending on where the damage is done. Research and methodology development in the field of toxicity in LCA is ongoing internationally, and there are many characterization methods available.

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