

Household Waste Collection Policies for Mercury-Containing Light Sources in Sweden

Status and Trends

Stefan Sipka

Supervisors

Thomas Lindhqvist

Thesis for the fulfilment of the
Master of Science in Environmental Sciences, Policy & Management
Lund, Sweden, June 2012

MESPOM Programme:

Lund University – University of Manchester - University of the Aegean – Central European University



**Erasmus Mundus Masters Course in
Environmental Sciences, Policy and Management**

MESPOM



This thesis is submitted in fulfilment of the Master of Science degree awarded as a result of successful completion of the Erasmus Mundus Masters course in Environmental Sciences, Policy and Management (MESPOM) jointly operated by the University of the Aegean (Greece), Central European University (Hungary), Lund University (Sweden) and the University of Manchester (United Kingdom).

Supported by the European Commission's Erasmus Mundus Programme



Education and Culture

Erasmus Mundus

© You may use the contents of the IIIEE publications for informational purposes only. You may not copy, lend, hire, transmit or redistribute these materials for commercial purposes or for compensation of any kind without written permission from IIIEE. When using IIIEE material you must include the following copyright notice: 'Copyright © Stefan Sipka, IIIEE, Lund University. All rights reserved' in any copy that you make in a clearly visible position. You may not modify the materials without the permission of the author.

Published in 2012 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191



Acknowledgements

I would like to thank my supervisor Professor Thomas Lindhqvist for cooperation. Through this cooperation, I have received plenty of useful information and new insights regarding my thesis topic. Furthermore, I learned more how to organize and conduct an academic research. I hope that in return this paper will also be useful for IIIIEE, CEU and other constituents of the MESPOM network.

I would also like to thank my family and friends for support and understanding during the thesis writing period. I am sorry for not being able to always give you the necessary attention.

Abstract

The thesis explores the possibilities of the Swedish government to assure effective waste collection policies for mercury-containing gas-discharge lamps (GDL) in the context of phase-out of incandescent light bulbs. The study includes review of the waste collection, the waste collection evaluation, policy review and policy analysis. The specific analytical tools applied include Lindhqvist's policy principle of extended producer responsibility (EPR), Melissen's Morphological chart and Wagner's convenience factor. Main waste collection forms consisted of municipal recycling centers, mobile collection points in rural areas, curbside collection, collection vehicle with fixed collection position and collection in store which is mainly in experimental phase. The results showed low GDL waste collection effectiveness and unclear estimations regarding collection rates. Key policy elements in Sweden were included in the Ordinance SFS 2005:209 and the Waste Ordinance SFS 2011:927. Ordinance 2005:209 transposed the EU Directive for waste electrical and electronic equipment (WEEE Directive) which strongly influenced the Ordinance SFS 2005:209. Both WEEE Directive and the Ordinance SFS 2005:209 introduced weight-based collection targets for the whole WEEE and limited producer responsibility for waste collection. Ordinance SFS 2005:209 did not transpose distributor responsibility. Main current policy limitations include lack of specific collection rates, unclear specification of responsibility for the collection of household waste and a lack of distributor responsibility. Further policy improvements might include deposit-refund system, financial and/or physical extension of producer responsibility to household waste collection and introducing liability of producers for the unsorted waste.

Keywords: Sweden, mercury, light source, policy, waste collection, household

Executive Summary

The implementation of the European Union phase-out policy regarding incandescent light bulbs in 2009 opened the space for the wider introduction of gas-discharge lamps (GDL) in Swedish households. GDLs contain mercury which is known for its hazardous features. If gas-discharge lamps are not sorted and treated properly once becoming waste, there is a risk that mercury would be released into the environment. Therefore there is a possibility for environmental risk to occur. Preliminary study of Swedish waste collection gave reasons for doubt regarding waste collection effectiveness in the situation when phase-out of incandescent light bulbs will cause an increase of gas-discharge lamps consumption in households. Therefore, the focus problem was formulated as the risk of ineffective waste collection in the context of phase-out of incandescent light bulbs in Sweden. The research question was formulated as follows:

How can Swedish policy makers achieve effective household waste collection of mercury-containing lamps while maintaining the phase-out policy for incandescent light bulbs?

Because of the practical reasons and efficient usage of available time and resources, scope of the work was narrowed to households, waste collection of GDLs, Swedish experience and policy perspective.

In order to answer stated research question, data collection was conducted and analytical framework was developed. Data collection consisted of literature review and qualitative research methods in the form of interviews.

Analytical framework included author's insights combined with the works of Lindhqvist, Melissen and Wagner. Lindhqvist developed a policy principle of extended producer responsibility (EPR) which gives sound arguments in favor of fair allocation of costs and responsibilities regarding waste management, efficient waste collection and potential for public support for increased environmentally-sound waste collection of GDLs. EPR was adopted as a guiding principle in this paper. However, in order to fully determine the effectiveness of household GDL waste collection it became important to develop an analytical framework for evaluating waste collection, waste policies and finding space for potential improvements. Wagner's study discovered that convenience is the single most important factor for residents' disposal behavior regarding compact fluorescent lamps (CFL), which is a sort of GDL mainly used in households. Melissen's Morphological chart provided useful analytical tool to evaluate existing waste collection and to come up with solutions for further development. Melissen applied four behavior factors regarded as important for residents' household disposal behavior concerning small electrical and electronic waste (WEEE): opportunity, capacity, motivation and established routines. The rest of Morphological chart included defining sub-solutions with the function of increasing stated four factors towards desired disposal behavior and formulating waste collection design alternatives (policy scenarios).

The author combined Melissens and Wagner's findings. Convenience factor was applied as a single primary factor while Melissen's four factors were used as sub-factors. These sub-factors would determine the convenience factor for general and specific waste collections. Convenience would serve as an indicator of waste collection policies' effectiveness.

The final analytical framework was designed to include four main stages. First, waste collection review was conducted. It consisted of research regarding current waste collection estimations and a review of the existing waste collection forms. This stage was based on data collection. Second, waste collection was conducted based on Melisson's four factors. These factors were considered as sub-factors in relation to main convenience factor. Waste collection

forms discovered through waste collection review were compared with the four sub-factors. Through logical reasoning waste collection was evaluated and the sum of the evaluations would determine both the convenience of the specific waste collection forms and the waste collection system in general. Third, a policy review was conducted in order to find out more about current policies, historical development and stakeholder opinions. Finally, policy analysis was conducted. It included analysis of the existing policies in order to determine their influence on waste collection, listing possible sub-solutions and policy scenarios. At this stage, Morphological chart was applied together with the findings from the waste collection review, waste collection evaluation and the policy review.

The results for the waste collection were that collection estimations are unclear. This is due to a lack of a commonly accepted calculation formula, features of GDL waste which cause difficulty when measuring product consumption (necessary for calculating collection rate) and because of the limitations of the pick analyses. Identified Waste collection forms include municipal recycling centers, rural collection points (with scarce data), curbside collection, collection vehicles with fixed collection points and collection in stores. Municipal recycling centers are the most commonly used forms.

Waste collection evaluation lead to the conclusion that except for collection in store, all other collection forms are generally inconvenient.

Municipal recycling centers are not close to households, require residents to have access to car, physical capability to access the system, and also include additional resident effort, money and time with low connection with established routines of the residents. These limitations make this solution inconvenient for disposal of GDL. That is because GDL is a small waste which will hardly motivate residents to visit distant recycling centers.

Curbside collection is at close proximity, however often associated with safety risks. This collection is compatible with established routines but also requires residents' to pay for the usage of this collection form.

Collection vehicles with fixed collection point are compatible with established routines but can be problematic because residents' must adjust to a particular time schedule.

Collection in store offers proximity to the house and is compatible with established routines. It can be regarded as the only convenient collection at this moment. However, this collection is still in experimental phase. In addition, all municipal forms in practice are mainly based on municipal waste management. This management is based in incomes received from residents through taxes and charges. The fact that residents have to pay for the collection, further decreases the convenience of the system, especially given the context that legally, producer are considered responsible. When existing collection system is taken into account, it can be said that the whole collection system is not convenient. Therefore, policies are not considered to be effective.

Policy review showed that Ordinance SFS 2005:209 contains the main rules regarding GDL waste collection. It transposed the EU Directive on waste electrical and electronic equipment (WEEE Directive) that GDLs were part of.

Ordinance SFS 2005:209 established the producer responsibility to accept consumers' waste free of charge and the responsibility to establish a collection system. Sweden used the option not to transpose the distributor responsibility offered in the WEEE Directive. Ordinance SFS 2005:209 transposed the WEEE Directive collection targets. These targets were based on total

collected weight of WEEE. Such target formulation might explain why difficulties are encountered regarding collection estimations. Since there is a lack of specific targets for GDLs and general targets are expressed in weight, there is less relevance of determining their collection rate.

In practice the collection system was established in such a way that municipalities remained responsible for local municipal waste collection while producers became responsible for collection containers, and transportation of waste from collection points towards treatment facilities. During 2000s municipalities started to demand greater share from producers in waste collection, however, local collection still remained mainly under municipal responsibility.

Another two pieces of legislation important to mention are: Waste Ordinance SFS 2011:927 which sets responsibility for residents to sort their waste and the Environmental Code where provisions regarding traditional municipal responsibility for waste collection are clearly stated.

Main policy debates relevant for GDL waste collection were basically about how collection targets were established and the role of producers in waste collection. Historical accounts of stakeholder opinions mainly included requests for the establishment of a deposit-refund system. Historical review also showed that there was an older Ordinance SFS 2000:208 which came to end when the EU WEEE Directive had to be transposed.

Policy analysis of existing collection system lead to the conclusion that the main policy elements responsible for current ineffectiveness of waste collection include: features of the established collection targets; lack of the exact specification of responsibility for household waste collection; lack of distributor responsibility; and the lack of producer liability for unsorted waste.

Collection targets were based on total weight of WEEE collected. Such formulation of the collection targets gave little incentives to producers and municipalities to establish a convenient household collection for small WEEE, including GDLs. Lack of specified responsibility for household collection resulted in a division of responsibility between municipalities and producers. Municipalities were left with the main role in local waste collection. This division was not, however, fruitful regarding household collection. It included allocation of costs on residents through municipal charges. This made it more difficult for municipalities to expand collection on household level. Lack of transposition of distributor responsibility decreased the chance of establishing collection in store for residents. Assigning sorting responsibility to residents decreased the incentives for producers, as well as, for the municipalities to create convenient household collection. That is because they could not be held responsible in case unsorted GDL waste occurred.

Next step in the policy analysis included listing sub-solutions and creating policy scenarios. Three possible policy scenarios were formulated containing specific sub-solutions to increase the convenience factor. Business-as-usual scenario relied on established cooperation between the municipalities and the producers with sporadic governmental interventions. Limited change scenario included introduction of specific sub-solutions such as distributor responsibility, more convenient curbside collection and deposit-refund system. Drastic change scenario included specification of the producer responsibility for household waste collection which might also come in combination with specific policy instruments such as deposit-refund system.

Finally, an answer to the stated research question was given by locating the area of effective policies in the two last scenarios and namely included: formulation of specific waste collection

targets for GDLs expressed in collection rate; deposit-refund system; specification of physical producer responsibility for GDL waste household collection; specification of financial producer responsibility for GDL waste household collection; introduction of distributor responsibility; and combinations of the former specific answers.

Table of Contents

LIST OF FIGURES	II
LIST OF TABLES	II
ABBREVIATIONS	II
1 INTRODUCTION	1
1.1 FOCUS PROBLEM	1
1.2 RESEARCH QUESTION.....	2
1.3 SCOPE & LIMITATIONS	2
1.4 DATA COLLECTION.....	3
1.5 THEORETICAL FRAMEWORK.....	4
1.5.1 <i>Extended Producer Responsibility as a Policy Principle</i>	4
1.5.2 <i>Convenience factor, Triad Model and Morphological Chart</i>	5
2 WASTE COLLECTION REVIEW	9
2.1 GDL WASTE COLLECTION.....	9
2.1.1 <i>GDL and Waste Collection Rates</i>	9
2.1.2 <i>Swedish Waste Collection Estimations</i>	10
2.1.3 <i>Collection rates</i>	10
2.1.4 <i>Pick Analysis</i>	12
2.1.5 <i>Accumulation in Households</i>	15
2.1.6 <i>Collection of Incandescent Bulbs</i>	16
2.2 WASTE COLLECTION FORMS.....	16
2.2.1 <i>Main Collection Forms</i>	16
2.2.2 <i>Alternative Forms of Waste Collection</i>	20
3 WASTE COLLECTION EVALUATION	25
4 POLICY REVIEW	29
4.1 HISTORICAL DEVELOPMENT.....	29
4.1.1 <i>Academic Research</i>	29
4.1.2 <i>Parliamentary Activities</i>	30
4.1.3 <i>Swedish WEEE Ordinance SFS 2000:208</i>	32
4.2 EXISTING WASTE COLLECTION POLICY	34
4.2.1 <i>EU WEEE Directive</i>	34
4.2.2 <i>Swedish Ordinance SFS 2005:209</i>	37
4.2.3 <i>Other Legislation</i>	40
4.2.4 <i>Stakeholders' Debate</i>	40
4.3 POLICY IMPLEMENTATION	44
5 POLICY ANALYSIS	45
5.1 CURRENT POLICY	45
5.2 POLICY SCENARIOS	48
6 CONCLUSIONS	50
6.1 SUMMARY OF THE PRESENTED RESEARCH.....	50
6.2 ANSWERS TO THE STATED RESEARCH QUESTION	51
6.3 FINAL REMARKS.....	51
BIBLIOGRAPHY	52
APPENDIX	55

List of Figures

Figure 1-1 Analytical Framework.....	8
Figure 2-1 Collection of WEEE in Collector from February 2009 until January 2010 (kg) 22	
Figure 2-2 Collection of CFL in Collector from February 2009 until January 2010 in kg.....	22

List of Tables

Table 2-1. Collection rate for waste lighting equipment in 2008&2009.....	11
Table 2-2. Collected amount of waste light equipment 2004-2008	11
Table 2-3. Amount of light equipment put on market & waste collected for 2008	12
Table 2-4. Amount of light equipment and GDLs put on market and amount of waste collected for 2009.....	12
Table 2-5 Amount of waste GDL collected in total per capita for 2010&2011	12
Table 2-6 Amount of waste FL collected for 2008&2009	12
Table 2-7 Collection of WEEE from Collector from February 2009 until January 2010 (kg) 20	
Table 3-1 Waste collection evaluation.....	27

Abbreviations

ÅVC – Återvinningscentraler (Recycling center)

CFL – Compact fluorescent lamp

CECED – European Committee of Domestic Equipment Manufacturers

CEMR – Council of European Municipalities and Regions

DSM – Demand side management

EC – European Commission

EEB – European Environmental Bureau

EEE – Electrical and Electronic Equipment

EPA – Environmental protection agency

EPR – Extended producer responsibility

EU – European Union
EUR - Euro
FL – Fluorescent lamp
FT – Fluorescent tube
GDL – Glass discharge lamp
HW – Hazardous waste
IIIEE – International Institute for Industrial Environmental Economics
LED – Light-emitting diode
MOP – Member of parliament
MRT - Mercury recovery technology
MS – Member State
NGO – Nongovernmental organization
PRO – Producer responsibility organization
SAKAB – National facility for handling of hazardous waste
SGÅ – Svensk GlasÅtervinning
SEK – Swedish Krona
SSNC – Swedish Society for Nature Conservation
SvD – Svenska Dagbladet
WEEE – Waste electrical and electronic equipment
ZMWG – Zero mercury working group

1 Introduction

1.1 Focus problem

Growing concerns regarding climate change and resource conservation influenced the European Union (EU) to adopt policies to increase its energy efficiency. In 2007 goals were formulated to reach 20% increase in energy efficiency by the year 2020 or 20/20/20 goals (EC, 2008). One of the measures taken to ensure the achievement of these goals was to increase energy efficiency in the lighting sector. The instrument used was a phase-out of energy inefficient light sources. Regulation 244/09 was enacted in 2009 as an implementation measure of the Ecodesign Directive 2005/32/EC. The regulation set time stages for the phase-out of different categories of energy inefficient light sources (EC, 2009). An important amount of these light sources were comprised of incandescent light bulbs used in households.

It is widely accepted that incandescent light bulbs convert 5-10% of its electricity to light, while the rest is converted into heat. Since unnecessary amounts of fuel are being consumed to deliver the primary function of the light source, incandescent light bulbs can be considered as energy inefficient. This fact was used by EU as one of the arguments to introduce a ban on incandescent light bulb starting from 2009 as a part of the phase-out process. Another argument for such a decision was the estimation that there were other energy-efficient light source alternatives already available on the market, however, due to established consumer habits they have not been fully utilized. This was the case although energy-efficient light sources were less expensive in the long term. In opinion of the European Commission (EC), short-term advantages of incandescent light bulbs prevented consumers to perceive the possibility of greater economic and energy savings (EC, 2011).

The phase-out decision provoked different opinions regarding its justification and usefulness. In this paper the focus will be given to the potential impacts of the phase-out policy on the waste management sector. Reasons for such a focus are concerns that the author encountered during formulation of the thesis topic regarding waste collection of energy-efficient light sources. The currently available alternatives are mainly halogen lamps and gas discharge lamps (GDL) that contain certain amount of mercury. Although there is an ongoing debate regarding required mercury concentrations in GDLs, it is widely accepted that mercury is currently necessary for the functioning of GDLs. The phase-out of incandescent lamps will lead to a high demand of GDLs on market, and in particular, in household sector.

Since mercury is considered as a hazardous waste (HW), it is important to ensure separate waste collection and treatment in order to avoid environmental risks occurring in the context of the phase-out policy. The necessity to conduct separate sorting is especially important in the case of compact fluorescent lamps (CFL), a type of GDLs, considered to be most appropriate for household use. Since incandescent light bulbs are largely utilized by households and therefore dependent on residents' behavior, concerns about CFLs waste disposal become increasingly important.

Preliminary research conducted through discussions with the supervisor and reading about the low collection figures for lighting in the EU in the 2000s raised doubts about the existence of an effective household waste collection. In the context of the phase-out process, the issue becomes more alarming, due to the potential environmental risk associated with increasing numbers of mercury-containing GDLs. Furthermore, public attention was raised in Sweden regarding improper disposal of GDLs from households, which influenced even the Swedish Government to act.

Association of municipal waste management companies “Avfall Sverige” (2011) summarized the problem with current collection system, in the following way:

The collection system can be described as extremely effective for larger products such as refrigerators, televisions, microwave ovens, vacuum cleaners, and the like. Almost all such appliances are collected these days and treated properly. The issue however is effectiveness of existing systems for the collection of small products. There is no evidence to suggest that large part of small WEEE are in nature in high volumes, but it seems that some of them are thrown into the trash instead of being separately submitted for recycling. Consumption of small WEEE is surging. It is therefore important to start planning for additional collection systems which can pick up tomorrow's all discarded small products (Avfall Sverige, 2011).

Moreover, Avfall Sverige (2011) considers that development of additional collection with better accessibility should be considered both for incandescent light bulbs and CFLs. The bulb is a product that is expected to constitute a smaller share in the waste stream in the future and subsequently to be replaced by CFLs. Introduction of CFLs will reduce the number of light sources due to their longer use phase. However, it is important that CFLs are separately collected because they contain mercury. Available pick analyses showed that few CFLs are being thrown into the household waste. However, there is a risk that the number of CFLs will increase as the consumption increases, unless a more accessible collection system is established (Avfall Sverige, 2011).

It is considered by the author that the problem of unsorted household waste collection of GDL, and especially CFL in the context of the phase-out process deserves academic attention. It is important to investigate if effective waste collection was established and what improvement could be made in order to prevent environmental risks.

The author decided that the focus should be narrowed to one Member State (MS) of the EU, which is Sweden, due to topicality and other reasons which will be outlined under the section concerning scope of the thesis.

The issue of waste collection of GDLs is regarded as largely connected with the implemented waste policies. Although there is a process of economic and technological introduction of GDLs into the market, in this case it is the policy (phase-out) that will significantly increase the supply of GDLs. The author considers that, if a phase-out is implemented, there should be an effective waste collection policy to prevent potential environmental risks associated with mercury emissions into the environment from unsorted GDL waste.

Subsequently, the focus problem of this paper is defined as risk of ineffective household GDL waste collection in Sweden in the context of the incandescent light bulb phase-out.

1.2 Research Question

Given the stated focus problem, the research question is formulated as follows:

How can Swedish policy makers achieve effective household waste collection of mercury-containing lamps while maintaining the phase-out policy for incandescent light bulbs?

1.3 Scope & Limitations

The scope of the study includes the following elements:

Geographical orientation – the study is mainly focused on Sweden. There are several reasons for such decision. First, Sweden is generally considered to be a country with high

environmental performance. Analyzing Swedish experience regarding waste collection may offer valuable insights. Second, time and resource constraints prevent broader research that would include several countries, the whole EU or an analysis at the global level. Strategic decision is to focus on a single country in order to produce effective results and to prevent the thesis of becoming superficial or a sum of meaningless accumulation of data. Third, the author spent nearly one year in Sweden as a part of his studies. Therefore, a pragmatic element is included to focus on the country where the second part of the study program was conducted, thus avoiding potential organizational complications. Nevertheless, relevant experience from other countries will also be taken into consideration. Finally, implications of the thesis findings at the EU level are considered as well.

Product orientation – the thesis is focused on GDL waste. There are direct and indirect reasons for this decision. Direct reasons include environmental risks associated with mercury pollution of GDL waste and the politically topical issue concerning waste GDL. The latter means that, the issue of GDL waste collection is currently under the public and the political spotlight. Therefore, the thesis may offer useful contribution in solving one environmental problem given the existing public discourse regarding GDL waste. Indirect reasons include future issues of waste from light emitting diodes (LED) and small electrical and electronic waste (WEEE) in general. LED is a light source with similar size to GDL, however still in its stage of development. Furthermore, it contains valuable scarce resources that ought to be recycled in order to assure their continual presence on the market. Small WEEE is a growing type of WEEE due to the general process of product miniaturization. Therefore, waste collection of these products, should be assured as well. Assessing waste collection policies for GDLs might, hence, offer valuable insights regarding both LEDs and other small WEEE. Finally, it should be noted, that expressions used to describe the studied product may vary in specific cases. Applied expressions include “gas discharge lamp” (GDL), “fluorescent lamp” (FL), “compact fluorescent lamp” (CFL) or “mercury-containing lamp”. The difference between FL and CFL is that FL is a broader concept which incorporates CFLs, but, also fluorescent tubes (FT) which are type of FLs mainly utilized by organizations.

Study discipline orientation – the thesis is focused on GDL waste collection from the policy perspective. In certain situations, policy analysis includes the aspects usually encountered in political science. The reason is that the author considered policy to be a very important factor regarding waste collection dynamics. Policies set general rules which reflect on concrete collection activities. Moreover, the author’s academic background in political science makes a choice of policy paradigm a logical outcome.

Waste source orientation – the thesis is focused on households, more specifically, residents’ disposal behavior in relation to waste collection policies. The reason is that households are an important source of GDL waste, especially during the phase-out of incandescent light bulbs. Furthermore, behavioral and legal differences make a division of waste collection in households and organizations a logical outcome. Consequently, higher level of organizational clarity and working focus is expected to be achieved, and limited space and time for thesis work is expected to be utilized in the optimal way. Waste collection in organizations will also be addressed at certain points although on a supplementary basis.

1.4 Data Collection

In order to answer the stated research question, data collection was conducted. Data collection relied on literature review and qualitative research method.

Literature review includes relevant legislation, academic articles, reports, newsletters and information available on websites of the respective organizations. All literature was accessed

through online search. Online sources for literature review include official organizations' websites and specialized data grids, such as Science Direct. Another way of accessing literature is through a snowballing technique. It consists of tracking relevant documents by using already existing ones, mainly through references.

Qualitative research methods consist of in-depth interviews and shorter communication with relevant stakeholders. In-depth interviews were conducted in a face-to-face communication while shorter communication was conducted through telephone or e-mail. Several stakeholders were contacted. However, only three responded and participated and provided data. For the purpose of the qualitative research a set of questions centered on certain thematic units were developed. When there was a possibility to do in-depth interviews, predetermined questions were applied although to a limited extent, since the dynamics of communication could not always follow the strict order of questioning. If questions could not be fully applied, they could still be useful for orientational purposes. In shorter and a more dynamical communication, thematic units were used for starting communication and for orientational purposes. The list of questions, thematic units and interviewed stakeholders, interviewed is located in the Appendix.

1.5 Theoretical framework

In addition to data collection, answering the stated research question also requires development of certain criteria and analytical framework. These analytical tools will be utilized to determine current and potential waste collection effectiveness.

1.5.1 Extended Producer Responsibility as a Policy Principle

Scarce research was found in available literature, regarding policies for environmentally effective waste collection systems for GDLs. However, research conducted by Lindhqvist (2000) on extended producer responsibility (EPR) might offer sufficient space for development of policy analytical framework.

Lindhqvist centered the concept of EPR around environmental product policy and the issue of responsibility for product waste. Traditionally, municipalities were held responsible for waste collection. They would introduce certain waste collection solutions regarded as financially and legally feasible. Resources for establishing such management often came from municipal charges. Except for general public resentment towards increased public financial burdens, the limitation of former approach was that charges would usually not depend on waste amount generated by the resident. Even if the source of waste amount could be identified inside municipality, residents would still be in a situation to pay for waste they were not responsible for. The concept of EPR suggests that producers should in fact assume responsibility for products they manufacture. The exact definition of EPR was as follows:

Extended producer responsibility is a policy principle to promote total life cycle environmental improvements of product systems by extending the responsibilities of the manufacturer of the product to various parts of the entire life cycle of the product, and especially to the take-back, recycling and final disposal of the product. Extended producer responsibility is implemented through administrative, economic and informative policy instruments (Lindhqvist, 2000).

EPR is compatible with polluter pays principle.

Producer responsibility may include several components:

1. Liability – responsibility of the producer for proven environmental damages caused by the manufactured product
2. Financial responsibility – responsibility of the producer to cover the expenses for waste management of the manufactured product
3. Physical responsibility – responsibility of the producer to provide physical waste management of the manufactured product
4. Informative responsibility – responsibility of the producer to provide information about environmental properties of the manufactured product

Therefore, EPR as a principle can be implemented totally or partially by using different sets of policy instruments.

There are three main arguments why EPR can be regarded as a useful policy principle when studying GDL waste collection. First, implementation of the EPR principle might increase the convenience and political support of the residents towards more environmentally appropriate waste collection. This is because the application of the EPR suggests a potential shift in responsibility from municipalities, mainly relying on resources provided by residents, towards producers. Second, switching responsibility from municipalities towards producers might lead to more efficient waste collection due to an introduction of private actors and potential market efficiencies. Third, the European Union formulated environmental policies that rely to some extent on producer responsibility regarding waste GDL collection. These policies consequently, affect Sweden as well.

It can be argued that the producers might cover the increased expenses associated with the new responsibility by increasing the prices of the products, hence, increasing discontent among consumers. However, potential increase in price will not affect the residents in the same way due to different consumption patterns. Appropriate implementation of EPR could also decrease residents' expenditures. If the municipality lost responsibility regarding waste collection, certain municipal charges might lose its justification. Furthermore, EPR principle offers the possibility of a fair allocation of costs. If a producer and a consumer of the product pay the price then actors most responsible for the introduction of a product into the economy and society will also internalize the costs of its waste management. Finally, EPR offers the potential of introducing product Design for Environment (DfE). This is because the producer might tend to change the design of the product to be more environmentally appropriate in order to lower the costs of waste management.

1.5.2 Convenience factor, Triad Model and Morphological Chart

There are certain limitations regarding direct implementation of the EPR into the analysis. First, EPR is still a general principle that needs to be scientifically examined in practical situation in order to determine its effects. Second, EPR may be implemented partially and, hence, may lead to different results when compared to the expectations set in the theory. In order to determine the effectiveness of certain policy, it is important to analyze how the household waste collection is implemented under the given waste policy. One way to achieve this requirement is to look at the estimations for waste collection. However, this approach may contain deficiencies regarding data collection, established targets or full potentials of waste collection policies. It is especially important to further identify the influence of a policy on the development of concrete management systems and to establish criteria for policy evaluation and improvement. Wagner and Melissen's studies provided further analytical tools to accomplish a substantial analysis of GDL waste collection policy in Sweden.

The study done by Wagner (2011) focused on explaining low household waste collection of CFLs in US state of Maine. Wagner tried to explain household behavior primarily through convenience as well as the knowledge factor.

Convenience factor was defined as “proximity to free collection”. Therefore, it included two elements: cost and proximity. Proximity included considerations about other routes that are either compatible or incompatible with the collection point (Wagner, 2011).

Wagner’s study is important because it directly researched the issue of GDL waste collection (more specifically CFLs), and linked the resident’s behavior with the level of convenience. Limitations of Wagner’s study are that provided definition of convenience is rather narrow. Furthermore, it is lacking an established analytical framework for evaluating policy effectiveness.

Study conducted by Melissen (2006) focused waste collection design in Netherland. Melissen applied Triad model and Morphological chart to analyze current and potential waste collection designs for small WEEE.

Morphological chart includes four basic elements: Triad model, sub-functions, sub-solutions and design of alternatives.

In order to evaluate current policy and management system regarding small WEEE waste collection, Melissen (2006) utilized the Triad model developed by Poiesz (1999), focused on residents’ behavior.

The Triad model relies on the premise that three factors influence residents’ disposal behavior:

1. Opportunity. To what extent do the circumstances beyond the control of the person favor or hinder behavior X (physical, material, weather, social and societal circumstances and available timeframe);
2. Capacity. To what extent does the person have the qualities, skills and instruments at his/her disposal to engage in behavior X (physical, mental and financial capacity, and tools and aids available to that person); and
3. Motivation. To what extent does the person wish to attain a certain goal, or to what extent is the person interested in engaging the behavior X (existing attitudes, appeals of rewards, and results that are brought about by engaging in behavior X) (Melissen, 2006).

Melissen (2006) also mentioned a fourth factor. However, because of an unclear reason, he did not include it into the Triad model. The fourth factor includes established routines that may influence resident’s behavior. The established routines factor is also included into this analysis.

Melissen (2006) did not explicitly mention when disposal has a certain level of environmental and health risk, for example, leakage, breakage, or inadequate level of waste separation. This issue will also be taken into consideration as a part of the opportunity factor.

Four behavior factors will further be measured regarding whether they resulted in a desired or undesired behavior.

Triad model is a useful analytical framework for evaluating existing policies. However, in order to come up with further suggestion regarding potential improvement in the system, it is important to apply Melissen's Morphological chart.

Sub-functions refer to improvement of behavior towards a desired alternative based on four behavioral factors. There are formally four subfunctions: "enhance opportunity", "enhance capacity", "enhance motivation" and "enhance routines" (Melissen, 2006).

Sub-solutions refer to possible policy instruments and management practices that serve the specific function. For example, deposit-refund can be a sub-solution regarding sub-function "enhance motivation" and educational campaign might be a sub-solution regarding subfunction "enhance capacity" (Melissen, 2006).

Through data collection and logical reasoning, sub-solutions can be derived. However, these sub-solutions still represent fragmented policy instruments which are not incorporated into a more coherent policy approach. That is why Melissen (2006) finalized his Morphological chart with the creation of "Design alternatives" for waste collection or in other words, policy scenarios. According to Melissen, this stage of work consists of analytically comparing every sub-solution. However, results would be somewhat artificial without reflecting real political situation and stakeholders' perception. Melissen (2006) himself stated that he relied on intuition to come up with waste collection design alternatives for small WEEE in Netherlands.

The author will combine findings made by Lindhqvist, Wagner and Melissen with his own insights in order to develop an appropriate policy analytical framework regarding GDL waste collection:

1. **Waste collection review.** This stage will rely on data collection;
2. **Waste collection evaluation.** This stage shall rely on results from waste collection review. Evaluation will be based on Wagner's findings regarding convenience factor for residents' disposal behavior and Melissens four factors (Triad model). Research conducted by former two authors, shall be incorporated in such a way that convenience factor for residents' waste disposal will be considered to be the main single factor determining the residents' waste disposal behavior. Convenience will further serve as a single indicator for determining the effectiveness of waste collection policies. Although knowledge is also considered as important for residents' disposal behavior, the author decided not to include it into the research. The reasons are the difficulties encountered regarding acquiring necessary data and evaluation. Therefore convenience factor will rely more on economic and infrastructural aspects. Furthermore, the author's assumption is that economic and infrastructural aspects may also have a potential of serving informative purposes;
3. **Policy review.** This stage will be based on data collection regarding relevant legislation and stakeholders' opinions. It will include both current status, and historical development; and
4. **Policy analysis.** This stage will include analysis of current policy regarding its influence on existing waste collection. It will be based on results from waste collection review, waste collection evaluation and policy review. Finally, results will be combined with Morphological chart with respect to EPR principle benefits in order to formulate future scenarios. The focus will be given on administrative and economic instruments. Sub-solutions and policy scenarios will serve as a final step towards the formulation of an answer to a stated research question.

Final look at analytical framework for GDL waste collection policy is presented in Figure 1-1.



Figure 1-1 Analytical Framework

2 Waste Collection Review

2.1 GDL Waste Collection

2.1.1 GDL and Waste Collection Rates

Collection rates of an appropriately disposed waste can serve as an important indicator regarding performance of the waste policy and management. It is estimated by calculating the share of the amounts of the waste collected of the total amount of product consumed during a specified period. Ways in which this calculation is conducted depends on the features of the specific product type. Level of ease and accuracy may also depend. For some types of waste, such as packaging waste, it is possible to compare the amount of collected product waste in one year it with the amount of product put on market same year. The reason is that the consumption of packaging has a rather short period (several months) and continuous use after the product has been sold. Furthermore, this kind of products is usually disposed shortly after it becomes waste. The consumption can be derived from accessible data regarding time of sale. Therefore, it is possible to calculate the share of the annually collected waste by comparing it with the annually consumed waste (Avfall Sverige, 2011).

The same, however, cannot be said for GDLs and WEEE in general because of several reasons. First, consumption of GDL is hard to predict based on the time the product was sold. The consumer does not continuously use the lamp. In some cases (bathroom or summer house) lamps can rarely be used which increases their use phase. Second, GDLs are designed to last longer, exceeding the year they have been sold. For example, FLs might have a span of several years. Lighting fixture might have a life span in the terms of decades (Avfall Sverige, 2011).

Contrary to packaging waste, there are clear limitations to derive consumption period from the time of sale. Therefore, other methods are applied. For batteries, for example there is a legally established formula in the EU Battery Directive 2006/66/EC for calculating the consumption from the product sale. However, there is no such formula officially defined for neither GDLs nor other WEEE. Instead, organizations which conduct the measuring, apply their own formulas thus increasing the space for arbitrary estimations.

Attempts have been made to calculate the “life tables” for EEE by using the same principles applied in population statistics. Despite much work being done, it has not fully succeeded. It is normally very difficult to find out the age of the products collected. Large and expensive devices can be marked indicating the year of the manufacture (or serial number which can sometimes give the year of production after contacting the manufacturer). However, most products have no such markings (Avfall Sverige, 2011).

Limitations of collection rate as an indicator is that, in some cases, the level of collection cannot suggest much, regarding the environmental risk. This is the case with waste containing hazardous substances. Limitations exist because of two reasons. First, even higher rates of collection do not have to imply that the environmental risk is not present, due to the hazardous feature of the material. It is possible to conduct an analysis regarding, for example concentration of the hazardous substance in environment, and, therefore, determine the danger of risks with more accuracy. However, without such risk analysis environmental risk from smaller amounts of unsorted waste products still exists. Second, although current concentrations of hazardous material from unsorted waste may be low, there may be a tendency towards their increase. This is the case with waste from products whose supply on

the market is increasing. Low share of unsorted waste may become less relevant because the amount of unsorted waste still increases due to the increase of the product consumption.

GDLs are an example of waste where the both mentioned limitations regarding collection rates have relevance. These lamps contain mercury which is known to be a hazardous substance. Furthermore, the supply of mercury-containing lamps on the market is expected to increase in order to substitute incandescent bulbs and other energy inefficient light sources.

EU collection rates for the collection of all lighting waste were estimated to be 27.9% for 2008 (UNU, 2008). Currently, there are no estimations regarding collection rates of mercury-containing lamps. Nevertheless the figure of 27.9% sends a clear signal that collection of lighting sources has been rather low. The issue receives increasing importance, if considered that presented estimation were given for 2008, that is, six years after the introduction of the new rules for the collection of GDLs and WEEE in general. Furthermore, the phase-out of energy-inefficient light sources began in 2009. Therefore, low estimation of collection rate of lighting sources for 2008 does not take into account changes in supply of light sources that occurred after 2009.

2.1.2 Swedish Waste Collection Estimations

2.1.3 Collection rates

Swedish collection rates are drawn from the collection estimations of “El Kretsen”, a company that collects most of the WEEE from local points and transports it for further treatment. A contact from Sweden’s lighting industry association “Belysningsbranschen” said that such estimations are based on the consumption of GDLs from the average sale in the past six years. This clearly represents the case how an organization tries to solve the difficulty of calculating the collection rate by setting its own rules. The official El Kretsen’s estimations state that the collection rate for 2008 was around 80% for all FL (El-Kretsen, 2009). That is also the year when such provisions of collection rates have commenced. Furthermore, before-mentioned contact from Belysningsbranschen confirmed that the FL waste collection rate is between 75% and 85%. However, an analysis of the available documents from El-Kretsen and other organizations will show that the relevance of this figure may be disputed both regarding its accuracy, and, level of households’ waste collection performance.

Tables 2-1, 2-2, 2-3 and 2-4 show the estimation of the light source waste collection rate taken from different documents of the Swedish Environmental Protection Agency (EPA) “Naturvårdsverket”. It can be seen that the specific waste collection of GDLs is not always separated from the total waste lighting equipment estimations. Moreover, EPA’s estimated collection rates for 2008 and 2009 are very low, especially compared to El-Kretsen’s estimations. It was not possible to acquire further information from Swedish EPA regarding the stated figure. EPA also showed the amount of GDLs both put on market and collected for the year 2009. On the other hand there are no specific data for GDLs put on market or collected for 2008, although El-Kretsen started to give specific estimations for GDL waste collection the same year. If EPA’s estimations for the amount of GDLs put on market and waste collected for 2009 are compared, the estimation will equal 60% of the waste share, somewhat similar to El Kretsen’s 2008 estimations. However, this kind of calculation cannot assure accuracy due to previously mentioned limitations regarding calculation of collection rate for GDLs.

Information retrieved from El-Kretsen documents is presented in Tables 2-5 and 2-6. It can be seen that there is a difference regarding how the waste collection of GDLs was presented for 2008&2009 and how the collection was presented for 2010 and 2011. In 2008&2009 case,

GDLs were classified as two separate categories: FL and CFL. On the other hand in 2010&2011 GDLs were presented as one single waste type.

When combining amounts of FTs and CFLs collected for 2008&2009 the total amount is similar to the amount shown for total GDL collection in 2010&2011. Furthermore amounts of waste GDL collected stated in El-Kretsen's documents basically equal the amounts of waste GDL collected mentioned in Swedish EPA's documents. That is because all of this information is essentially derived from El-Kretsen's estimations on the collected waste amounts.

Differences, however, occur regarding collection rate estimations. While El-Kretsen estimates collection rate to be around 80%, Swedish EPA claims that collection rate is less than 20%. As with the EPA, it was not possible to get further information on how El-Kretsen estimated collection rate to be at such a high level.

Available information from El-Kretsen's documents provides space for doubt regarding effectiveness of CFL household waste collection. Table 3-6 shows that smaller share of the collected GDLs consist of CFLs which are mainly used in households. Instead, a larger share is taken by the FTs which are mainly used in organizations. Lack of information regarding estimation of CFLs consumed and put on market limits the space for estimating their waste collection rate. Nevertheless, the claim made by El-Kretsen that around 80% of GDLs is being collected receives a lower importance because only a small share of that percentage consists of CFLs.

Therefore, it could be said that available information regarding household GDL collection rate estimations leads to certain difficulties. This is due to lack of common measuring methodology, differences between stakeholders' estimation and lack of precise estimations for collected household GDL, especially CFLs.

Table 2-1. Collection rate for waste lighting equipment in 2008&2009

	2009	2008
Lighting equipment (without GDLs)	5.7%	17.9%
GDL	19.5%	17.9%

Source: Naturvårdsverket, 2012

Table 2-2. Collected amount of waste light equipment 2004-2008

Lighting equipment (in tons)				
2004	2005	2006	2007	2008
5800	6700	7990	7893	6255

Source: Naturvårdsverket, 2010

Table 2-3. Amount of light equipment put on market & waste collected for 2008

	Lighting equipment (without GDL)
Put on market	15 691 048
Collected	3 804 668

Source: Naturvårdsverket, 2011

Table 2-4. Amount of light equipment and GDLs put on market and amount of waste collected for 2009

	Lighting equipment (without GDL)	GDL
Put on market	11 170 698	3 141 269
Collected	2 093 848	1 898 919

Source: Naturvårdsverket, 2011

Table 2-5 Amount of waste GDL collected in total per capita for 2010&2011

GDL		
	2010	2011
Total GDL waste collected (kg)	1 984 090	2 217 661
GDL waste collected per capita (kg)	0.211	0.23

Source: El-Kretsen, 2012

Table 2-6 Amount of waste FL collected for 2008&2009

	2008		2009	
	CFL	FT	CFL	FT
Total waste collected (kg)	461 898	1 865 934	425 716	1 616 115
Waste collected per capita (kg)	0.050	0.204	0.046	0.173

Source: El-Kretsen, insamlingsresultat 2008 & 2009

2.1.4 Pick Analysis

Limitations of collection rate estimations might be supplemented with a more indirect kind of analysis. One such way is to investigate whether WEEE shows up in places other than in the designed collection systems.

There is no indication that Swedish households to any great extent dispose WEEE into the nature (Avfall Sverige, 2011). It is more likely that some WEEE ends up in the regular trash at least for small WEEE that easily fits into a waste bin or can be pressed into a waste bin or a waste container. To what extent this happens can be derived by pick analysis.

Pick analysis is a method to find out what is included into the bin and container waste by household residents. The results could be used by municipal waste planners for various purposes such as to evaluate existing waste sorting system and to plan information campaigns. The way to perform pick analysis has become increasingly standardized in the last decade.

Simple overview of the method for pick analysis is as follows. First, it is determined which type of waste is to be studied and from which type of housing it will be retrieved. The waste is collected in a usual way. However, it is transported to a specially prepared sorting place. Next, it is tipped into a hard surface, mixed and then divided evenly into piles about one meter thick. Over the waste is a grid that further structures the waste into smaller boxes. With the help of chance a number of boxes are being selected to analyze the contents. All waste which piles are being lifted into a special table, where the staff sorts out the contents in various types and weighs it. The number of fractions can amount to 20-30 pieces depending on the waste and purpose of the analysis. The sorting is done with delicate care with different scales used. The work is very stressful, and staff needs for hygiene reasons to wear protective clothing. Therefore, each survey is limited to include 500-1000 kg. Such an inquiry may for example be composed of five sub-samples, each weighting 100 kg. The procedure is adapted to widely present fractions, such as food waste, paper and packaging. The fact that they are so common is not very important (Avfall Sverige, 2011).

However, it is the waste that occurs to a small extent such as WEEE that is important. For example in a box there might be no WEEE at all, but in the neighboring box there might be a speaker that weights 10 kg. The sub-sample results in the first case in 0% and in the other 12.1%. This example is taken from a survey conducted in one unnamed municipality in 2007. The example demonstrates a large role of chance in the final result. Since randomness plays a significant role in the individual picking analysis, the tendency is that these investigations are based on as many pick analyses as possible (Avfall Sverige, 2011).

2.1.4.1 WEEE in Household waste

Random testing from a total of about 40 municipalities has been conducted and compiled by Avfall Sverige. In the final data processing, studies were included, which were implemented from autumn 2005 to spring 2008 (Avfall Sverige, 2011).

Data was derived from 63 studies. Pick analysis was conducted on the waste fraction named "combustible, mixed waste". The name implies that that food waste was included. The results showed the high variance in different waste samples regarding the presence of WEEE. The six lowest results included 0% WEEE while the six highest results were from 1.4 to 2.6%. The median was 0.4 and the mean for WEEE fraction for all results was 0.6% (Avfall Sverige, 2011).

Many municipalities are changing their system of separately collecting organic and other combustible household waste. The aim is to influence residents' behavior towards separate collection of household food waste for anaerobic digestion or composting. In the collected material are relatively few data regarding this type of collection scheme. The pick analysis which presents data from such systems clearly showed that the organic fraction is almost completely free from WEEE. Only in two tests WEEE was discovered, however, in small amounts. In both cases, the amount included light bulbs. Instead, WEEE often occurred in the

other household waste fraction. The average (mean) acquired through pick analysis in this case was 0.9% of WEEE. This value is slightly higher than the 0.6% previously reported by municipalities. However, it is difficult to say with certainty if the actual amount of WEEE is greater, equal or slightly smaller (in terms of kg) in municipalities with household waste diversification compared to the municipalities that did not adopt the diversification of organic waste. The reason is that very few observations were included in the material. Nevertheless, available data may still suggest to some extent, that the household that sorts organic waste, also tries to keep this fraction cleaner (Avfall Sverige, 2011).

It would be interesting to use the collected data from pick analyses to obtain a more general knowledge about how various background factors such as demographic composition, advocacy or access to waste collection for WEEE affect the sorting of WEEE. Unfortunately, the necessary background information has not been documented sufficiently (Avfall Sverige, 2011).

However, it is possible to say something about the type of WEEE encountered. The most frequently occurring products are batteries and light bulbs, followed by wires, cables and various connectors. Small lights, flash lights watches and toys were also common. Furthermore, data showed that other WEEE found included hand mixer, electric razors, electric toothbrushes, hair dryers, calculators, keyboard computers, hard drive, circuit boards, radios, CD players, and similar products. FTs and CFLs were present, however in smaller number. An essential part of the identified WEEE was not covered by producer responsibility. More specifically, it could be identified as construction waste (cables, sockets) that could be encountered in households (Avfall Sverige, 2011).

Based on the presented findings, estimation was made of the total amount of WEEE that ends up in household waste. The estimate is pointing to a figure of approximately 12 000 tons of wrongly sorted WEEE per year or about 1.3 kg per capita. It should be noted that the uncertainty is considerable. Sorting analysis appears to be conducted very carefully. However, it still included only 100 tons of waste. That is 0.005% of the amount of the household waste generated in Sweden each year (more than 2 000 000 t). Moreover, it is also important to note that this estimation includes all WEEE found in the product analysis, ranging from “heavier” computer monitors to “lighter” bulbs. How much of this estimation was comprised of small WEEE was not discovered in this investigation. Therefore, as with the case of collection rates estimations it can be seen that limitations clearly exist regarding pick analysis for GDL waste as well (Avfall Sverige, 2011).

2.1.4.2 WEEE in other waste fractions

There are few pick analyses comparable with domestic waste regarding waste from outside the household. A small pick analysis performed for the year 2007 included waste from companies located in urban areas, probably shops, offices or restaurants. This waste was considered equivalent to household waste. It contained large fraction of food waste. It further included other waste fractions such as those present in household waste (newspapers and packaging). The presence of WEEE in companies’ waste also resembled that found in household waste, both regarding quantity (0.6%) and composition (cords, remote controls, broken toys and light bulbs) (Avfall Sverige, 2011).

EPA asked a governmental commission to investigate if the current system for collection of household waste should be replaced by another based on the products’ material content rather than its use. To obtain the underlying data a study was performed in Eskilstuna in 2007 regarding collected packaging waste fractions. Two small sections of plastic packaging were analyzed. One section included plastic packaging collected through recycling. It contained 0.5

kg WEEE or 0.6% (type of WEEE unknown). The second part included plastic packaging collected in a curbside collection. It did not include WEEE at all (Avfall Sverige 2011).

The same type of analysis was conducted for metal, however, for somewhat larger amounts (246 units or 180 kg). Metal fraction collected through recycling contained 2.6% WEEE while metal collected through curbside collection contained 1.3 % of WEEE. This was obtained from waste metal collecting company “Metallkretsen”. It recently investigated the content of their intermediary storage of collected metal packaging in eight locations in Sweden. In 2007 a total of 900 kg of WEEE was analyzed, which turned out to contain a total of 2% WEEE (Avfall Sverige, 2011). The result was commented upon by the investigator as follows:

WEEE such as lamps, cables, cell phones, microscopes, thermometers, switches, circuit boards, clocks, charges, headphones, was found in several samples. In total there were 20 light bulbs in samples. The sample from Malmö contained a computer, which constituted the majority of the sample weight. Large products such as computers appearing in the metal packaging seem to be rare. The Metallkretsen has designed inlets on their collection containers at recycling stations so it will be difficult to input larger WEEE. The WEEE found in the sorting process, is sent to El Kretsen without costs. Although the WEEE found is obviously an inconvenience and burden for the sorters, it should be noted that the waste is a small fraction of all external material found in the plastic and metal packaging. (Avfall Sverige, 2011)

Based on the presented findings, estimation was made of the total amount of WEEE disposed improperly, including plastic and metal packaging. It indicates that the amount can vary from 150 tons to 700 tons per year. That is around 0.1 kg per capita. However, it should be noted, that there is also a considerable uncertainty associated with these findings (Avfall Sverige, 2011).

2.1.5 Accumulation in Households

According to Avfall Sverige (2011), there is a reason to believe that there is a large amount of WEEE in Swedish households that is not being actively used or being broken. These items are retained somewhere in the household even if the residents purchased new equipment.

In order to investigate how Swedish households manage their WEEE an opinion survey was conducted during March 2008 by GfK Sweden AB. The survey, involved a total of 1000 people, in a nationally representative, random selection of men and women aging 16-84 years. In addition to questions regarding management of WEEE questions included an interview about age, sex, household size, number of children under 18 years old, type of housing, the household's total income, and the type of residence (Avfall, 2011).

Among other things, the respondents were asked if they had any non-functioning small WEEE in house. The survey showed that 65% of all people interviewed had discarded batteries at their home, 43% discarded light bulbs, 41% discarded cell phones, 37% rejected, watches, 24% discarded CFLs and fluorescent tubes, 22% rejected music player, 21% rejected toys, 15% discarded power tools, 11% discarded toothbrushes, and 18% other types of discarded WEEE. The accumulation was shown to exist in all types of households, but is slightly more frequent among families among households that describe themselves as environmentalists (Avfall Sverige, 2011).

The interviews suggest a significant accumulation of discarded, non-functioning products in the households. In reality, accumulation is probably even greater than what respondents stated in the interviews. This is because it can be difficult for the respondents to quickly recall all the products they have in their possession. Another reason is that respondents may have a lack of knowledge what products other member owns (Avfall Sverige, 2011).

2.1.6 Collection of Incandescent Bulbs

Information regarding collection of incandescent bulbs might be useful, because current resident's disposal practices might influence disposal of growing amounts of GDLs. A total of 70-80 000 000 light bulbs is sold per year in Sweden. This figure includes all types of light bulbs consumed both by households and non-households. Statistics for 2007 show that nearly 20 000 000 light bulbs were recycled this year, representing 25% of the new sales. The survey conducted by Avfall Sverige shows that 43% of households have a small storage of light bulbs. The reason is probably that residents wait for appropriate time to leave the light bulbs to an appropriate collection point. It is reasonable to assume that the new sales and consumption are roughly equal, around 80 000 000 bulbs annually. In Sweden, a collection of light bulbs on a large scale occurred only after the introduction of the producer responsibility in 2001. The amount was small for the first few years. However, it gradually increased and amounted to 430 tons in 2007 (Avfall Sverige, 2011).

The amount of non-recycled bulbs can be estimated to be around 60 000 000 in 2007 or 1300 tons. When distributed evenly among the whole Swedish population the result will be about 6 light bulbs or about 0.15 kg per year per capita. An average Swede disposes 240 kg of household waste annually. If all 60 000 000 light bulbs went into the household waste, there would be about 25 bulbs per ton of household waste equaling 0.06% of the weight share. Therefore, light bulbs by weight would comprise a maximum 10% of electronic waste, which remains in the residual household waste (Avfall Sverige, 2011).

Pick analysis shows that light bulbs together with batteries and other small WEEE, are usually thrown into the household waste. The reason may lie in a combination of several factors:

- Light bulb is a product that exists in large number in every household;
- Light bulb is small and fits easily into the household waste;
- Refuse bin is a more convenient/more accessible alternative than special collection points intended for incandescent lamps; and
- Lack of knowledge and motivation for households to sort out the light bulbs (Avfall Sverige, 2011).

From an international context, Swedish collection of light bulbs is actually considered to be efficient. An organized, nationwide collection of bulbs are normally not present in other countries. In EU, producer responsibility for WEEE does not include incandescent light bulbs.

2.2 Waste Collection Forms

2.2.1 Main Collection Forms

2.2.1.1 Recycling center

Majority of residents usually dispose their small WEEE at the municipal facilities for collecting bulky waste (ÅVC). This is particularly true for older population with access to car (El-Kretsen, 2011).

There is a total of 650 ÅVC in the country (IIIIEE *et al*, 2007). For a relatively large country with population of nearly 10 000 000, the number of ÅVCs can be considered as rather small. Usually there are few of ÅVCs per community depending on the community's size. However, concentration of ÅVCs regarding population density may vary. In Västerås community with 130 000 residents, there are 10 ÅVCs, while in Lund municipality with 80 000 residents, there

are two ÅVCs positioned in peripheral areas. In Malmö, there are two recycling centers for 290 000 residents while in Gothenburg there are five recycling centers for 500 000 residents (Avfall Sverige, 2010). ÅVCs are staffed reception places for receiving household and garden waste, hazardous waste together with WEEE. They are mainly designed to be accessed with cars. Expenses are covered by municipality through municipal tax (Avfall Sverige, 2011).

WEEE is sorted normally in six fractions:

- Refrigerator;
- Large household appliances, fireplace, laundry dishwasher, oven/fryer;
- Small and medium sized appliances, including everything from USB flash drives, toys, phones to computers, microwave ovens, vacuum cleaners, TVs etc...;
- Fluorescent tubes;
- Other gas discharge lamps; and
- Incandescent bulbs (Avfall Sverige small WEEE).

Personal investigation and contact from Avfall Sverige indicated that today GDLs are not actually separated in ÅVCs. They are, instead, contained together in a single compartment. According to contact from Avfall Sverige and personel from two AVCs near Lund, the reason why there is no separation is because El Kretsen has recently introduced new technology for sorting during pretreatment process. Furthermore, at this point, it should be noted than initially incandescent bulbs were considered part of the same WEEE category together with GDLs.

2.2.1.2 Collection centers in smaller towns and rural areas

The next common collection sites according to the responses from GFK (Gothenburg) Sweden AB survey are municipal collection systems in smaller towns and rural areas (El-Kretsen, 2011). These may include unmanned and sometimes mobile recycling stations (Avfall Sverige, 2008). Little information was available on this form of waste collection regarding waste GDL.

2.2.1.3 Curbside Collection

Curbside collection of HW occurs mainly in southern and central Sweden. It is used to collect different kinds of hazardous waste (HW) including WEEE. What type of HW is collected varies between municipalities. Acquired studies sometimes take into account specific features of WEEE while sometimes consider HW in total. Around one third of the municipalities apply curbside collection. Among the municipalities that collect the HW via curbside are small and large municipalities, individual towns and municipalities in the regional collaboration (Avfall Sverige, 2009). Curbside collection is mainly used by residents in rented apartment in the city without access to car. (El-Kretsen, 2011)

The system for curbside collection includes both the solutions for the storage at the property as well as a vehicle for collection and transport (Avfall Sverige, 2009).

The curbside collection of HW always occurs in a combination with drop-off at recycling centers or unmanned recycling stations. Building-based collection of HW is applied by a large number of municipalities with different types of solutions regarding household type, logistics for collection and the level of service (Avfall Sverige, 2009).

Examples of specific solutions for the storage of HW on the property in anticipation of the collection are:

- Red box (lockable) – a special case given to residents to put store their HW until pick-up;
- Red box (not lockable);
- Lockable place in the building of apartment areas; and
- Special cabinet.

Except for curbside collection of HW from a designated place to waste collection point, there is a possibility for a resident leaving HW directly either to the caretaker or collection personnel. The latter process is called personal handover (Avfall Sverige, 2009)

The logistics are mainly organized in two forms:

1. Special pick-up including specially adapted collection vehicles; and
2. Pick-up coordinated with the regular garbage collection.

The most common collection solution is the collection via special tour.

Service levels in the system, or how often the HW can be retrieved, can be:

1. Summoning on a year basis;
2. Specific summoning weeks; and
3. Scheduled download.

The most common level of service is a summoning on a year basis. It is offered in around 40% of the municipalities that have adopted curbside collection of HW. The next most common is a scheduled download which is applied in around 25% of the municipalities that have adopted curbside collection of HW. Campaign collection in special weeks was applied in around 20% of the municipalities (Avfall Sverige, 2009)

The amount of HW collected via curbside is estimated to be rather small, an average of 0.050 kg/capita or about 2% of the total amount of collected HW. Of the amount of collected HW via curbside a share of 70% comes from so called traditional HW (chemicals, waste oil, paint, adhesives, and solvents). About 30% is made up of small batteries, car accumulators and light bulbs. What kind of HW is collected via curbside depends on the type of a system in place and in what type of building category does the system occur. Municipalities that have adopted the collection of HW with the red box usually offer no curbside collection of bulky WEEE or car accumulators. Municipalities that have the collection of HW from lockable place in apartment buildings, usually get most types of HW (Avfall Sverige, 2009)

Curbside collection is contained in both one family houses and apartment areas and in both urban and rural areas. Most common is curbside collection in family houses (Avfall Sverige, 2009).

In one family houses, a red plastic box is usually distributed to households, either to all or to those who make an active order. The box can include a label with handling instructions. The box stores residents' HW, preferably well marked in the original packaging. When the box is full, residents call the municipality and order for retrieval. To reduce the risk for various kinds of HW coming into contact with each other in the box while waiting for removal, there are some municipalities assigning households to put some HW such as WEEE or batteries into a

special packaging before it is placed into the box or to put it aside next to the box. Sometimes red boxes are divided into several compartments (Avfall Sverige, 2009).

In apartment areas, pick-up with personal handover at the apartment door is one of the several solutions for curbside collection of HW at the apartment areas. Resident contacts the local municipality and orders retrieval. The download process is then either left for the next scheduled collection time or for the time appointed with the customer. The download is to be implemented in a reasonably rational way. Restrictions include certain minimum number of items or minimum amount of HW to be downloaded in a session. Another model includes a drop off performed in an unoccupied space as prepared by the resident. The space is provided with a lock so that only residents of the area may have admission. Furthermore, it is possible to have unmanned drop-off in HW via special cabinet. Waste, often embedded in a red box, is further placed into a cabinet instead of directly being placed on a shelf in a conventional waste space. This solution is in some respects more secure solution than directly utilizing the room for waste. HW can be submitted by the resident to a caretaker or equivalent, who then sorts the waste and ensures that unauthorized access to the area is prevented. This requires additional work from the caretaker and that he or she has the relevant training (Avfall Sverige, 2009).

Certain HW including GDLs is part of the producer responsibility however, this was not perceived as a problem for the municipalities interviewed. However, residents are not always aware of what authority is responsible in each waste case. Producer responsibility is also associated with some financial difficulties. Compensation from the producers is usually less than the actual cost. Municipalities seek to some extent higher level of service for the residents and that producers take some kind of responsibility (Avfall Sverige, 2009).

The cost of curbside collection is mainly covered by the refuse collection fee. Municipalities generally lack comprehensive picture regarding system costs for curbside collection of HW. Municipalities have either not monitored the costs or present costs in different ways which happens in many cases to be too general. According to contact from Avfall Sverige charges for curbside collection are not always specified for each household. Sometimes they are included in general waste taxation. In general, interviewed municipalities do not account for the curbside collection of HW in such a way that the data can provide a basis for assessment of the costs for different types of solutions for curbside collection (Avfall Sverige, 2009). Collection costs may have a high variance such as, for example, curbside collection in Järfälla community. Total number of houses receiving red box for 2009 was 10 867 pieces. In 2009, 650 orders for retrieving the red box at the property were made. Costs were estimated SEK 3-4 SEK per kg except the red box collection which was SEK 37 per kg. This difference is because some curbside collection schemes involved collection of larger appliances which is not the case with the red box (El-Kretsen, 2011). There are also examples of eco-fees where the property owner pays a lower fee when having a space for the storage of HW for curbside collection on the property. This model is for example applied in Järfälla community. This design is intended to provide incentives for property owners to invest in the HW cabinet (Avfall Sverige, 2009).

2.2.1.4 Collection by Vehicle with Fixed Collection Site

Collection by using a vehicle with fixed collection site is conducted according to a predetermined schedule. The vehicle visits a number of collection sites in several municipalities. Collection with these vehicles may be suitable both in rural areas where the distance to the nearest AVC is far or in urban areas (Avfall Sverige, 2009, El-Kretsen, 2011).

2.2.2 Alternative Forms of Waste Collection

Several new collection schemes are offered by municipalities, sometimes cooperating with El Kretsen. The specific features of these collection schemes are that they are a relatively new phenomenon and often in experimental phase. Their current collection effectiveness is still limited or not fully determined. However, they possess potential for further development. Important opportunity was recognized in a possibility to establish collection in, or near stores.

From February 2009 to January 2010 a project was conducted in cooperation between contracting waste management companies Sysav, Renova and Vafab. All of these contractors were owned or hired by municipalities and usually covered specific regions where they offered waste collection services (Avfall Sverige, 2010).

The project included both supermarkets and stores specialized for EEE. Specially designed container named “Collector” (Samlaren) was placed inside stores. Collector was developed by Renova in cooperation with students of design from Chalmers University of Technology. The collector contained six openings for different small WEEE including two for GDL. Behind the frontal part are plastic crates where the injected waste was stored (Avfall Sverige, 2010).

The amounts shown in table 2-7 are the sum of the amount collected in all stores for each month.

Table 2-7 Collection of WEEE from Collector from February 2009 until January 2010 (kg)

	Incandescent bulbs	Batteries	Compact fluorescent lamps	Other small WEEE	Total

February	42	147	20	48	257
March	89	213	23	54	379
April	96	194	21	73	384
May	36	250	15	46	347
June	35	199	18	43	295
July	52	267	20	63	401
August	35	178	14	37	264
September	58	289	25	88	460
October	67	229	37	89	422
November	65	147	30	79	321
December	139	353	38	122	652
January	127	353	43	71	593
Total	840	2 819	304	812	4 775

Source: *Avfall Sverige, 2010*

Therefore, around 5 000 kg of WEEE was collected during one year of the project or 65 kg per month in each tank.

Data regarding collected WEEE and collected CFLs are presented in figures 2-1 and 2-2.

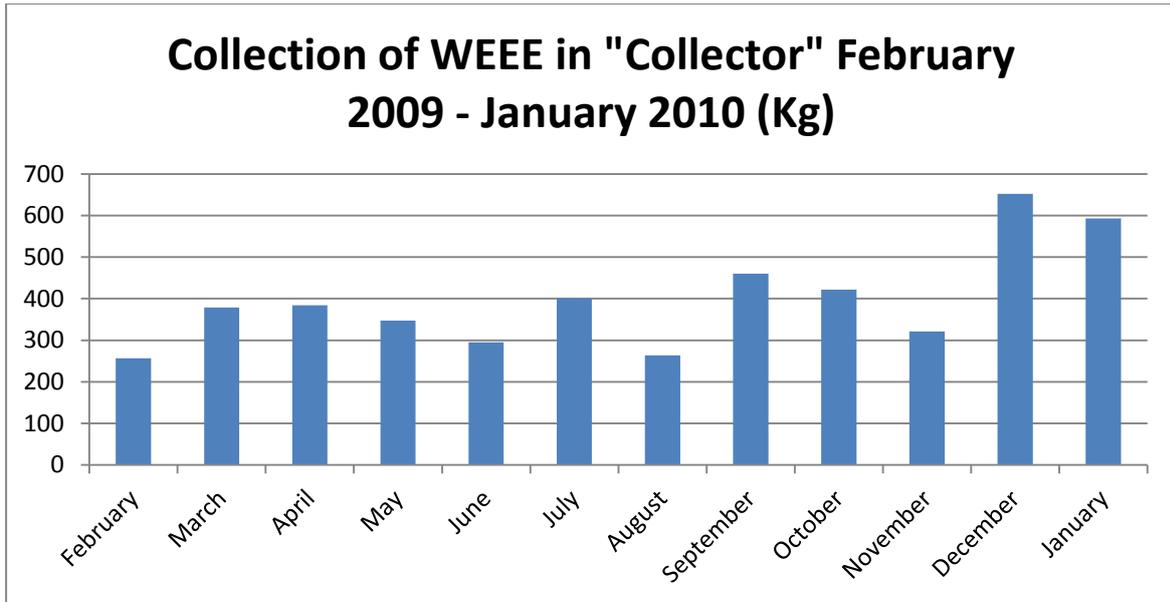


Figure 2-1 Collection of WEEE in Collector from February 2009 until January 2010 (kg)

Source: Avfall Sverige, 2010

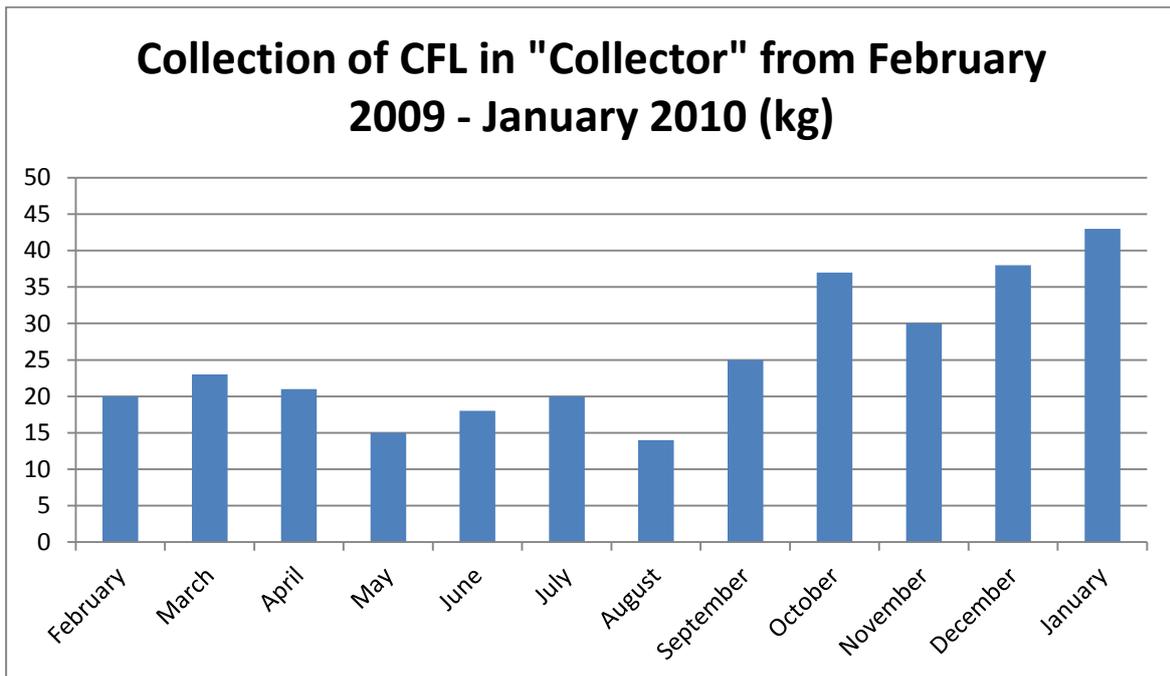


Figure 2-2 Collection of CFL in Collector from February 2009 until January 2010 in kg

Source: Avfall Sverige, 2010

There is was a slight upward trend over time for the amount collected per month, both for CFL and WEEE collection. The implication might be that new customers are still discovering the opportunity to use the Collector (Avfall Sverige, 2010).

Recently a new type of smaller and cheaper Collector with three holes (including CFLs) was developed (Renova, 2011).

According to Avfall Sverige's contact, new estimations include the figure of 60-70% municipalities having at least one Collector a total of 100-200 Collectors already bought.

The issue of financial responsibility for the Collectors is not yet clear. It is expected that this will be one of the main subjects during new negotiations between El-Kretsen and Avfall Sverige. However, it seems that currently costs are being covered by municipalities for Sysav, Renova and Vafab operations regarding Collector in store (Avfall Sverige, 2010).

Comparative analysis was conducted regarding collection results in areas covered by Renova, Sysav and Vafab AB. Renova had the highest collection rate per person, 1.1 kg, followed by Sysav, 0.8 kg, and, Vafab, 0.14 g. The explanation offered for the highest collection rate in the Renova region was that Renova had trial period since February 2007. Therefore, the consumers had more time to develop awareness of the collection scheme (Avfall Sverige, 2010).

In Västerås, the largest community in Vafab region, there was a well-established collection system independently of Collectors. In an area of 130 000 there are with AVCs in operation for 10 years. In comparison Malmö (Sysav area), has two recycling centers for 290 000 residents while Gothenburg has five recycling centers for 500 000 residents. According to Avfall Sverige, high amount of recycling centers for smaller populations may be the reason why in Vafab AB area there is less amount of waste collected (Avfall Sverige, 2011).

A comparison was made between different types of stores. Results show that collection is 30% lower in stores with electrical equipment when compared to grocery stores. The explanation offered by Avfall Sverige is that consumers are already used to returning other waste to grocery stores. Therefore, Collector in store was compatible with already established recycling habits. Moreover, groceries are, in general, visited more frequently than stores for EEE (Avfall Sverige, 2011).

Research also showed that waste samples are separately collected with low level of intermixture. The highest amount of mixing actually occurs when full containers were being carried away. Nevertheless, according to Avfall Sverige, plastic bags in Collector were designed to keep resilience under pressure (Avfall Sverige, 2010). However, according to El-Kretsen, risks of CFLs to break still is exists (El-Kretsen, 2011).

Collectors were overseen by the store personnel, usually together with other waste collection points in store. Waste management companies organized collection of full collectors by trucks. The frequency of trucks arrival depended on the specific case (Avfall Sverige, 2010).

Organizers experienced complications with legislation requirements during the testing period. Storage of small WEEE is regulated by the Ordinance on environmentally hazardous activity and health (1998:899). Under this Ordinance temporarily storing of hazardous waste has to be notified to municipal environmental department. Since Collector contains hazardous waste, stores were obliged to conduct notification. Except for being an administrative burden, regulation also included annual supervision by the municipal authority. This supervision was covered by fee that a temporary holder of hazardous waste (store) has to pay. Eventually waste management companies were required to pay the fee and carry the administrative burden. Financial responsibilities were different across municipalities. The fee could go from SEK 750 per year for two collection points up to SEK 5800 per year for a single collection point. In order to reduce the administrative and financial burden for waste companies, the EPA suggested to the Government that certain hazardous waste should be exempted from notification requirement. Until now no decision has been made (Avfall Sverige, 2010).

However, in El Kretsen's opinion, administrative and financial costs due to regulations for temporary storage of hazardous waste is considered to be marginal compared to other costs (El-Kretsen, 2011).

Cost of one Collector was estimated at SEK 40 000. Lifetime of the Collector was 10 years. Therefore, a yearly cost was estimated at SEK 4000. Transport costs for retrieval of waste depended of the frequency of retrieval that needs to be done, how much waste is collected, and how many access points there are that can be emptied at any time and distance between the collection sites. Avfall Sverige (2010) projected that costs for transportation regarding one collection point on average was estimated approximately at SEK 6000 per year. In total, the cost per collection cost was therefore SEK 10 000 per year.

Another store collection existed in Örebro community in 2000/2001. Collection wagon containing boxes was placed at the entrances to grocery stores of various sizes in the main town and also in smaller towns in the municipality, in the mall in the center and in some stores for EEE. Currently there are vehicles in 17 locations. The system is intended for those household residents who can't have curbside collection. Costs are estimated at around SEK 3000 per wagon with boxes. The download is estimated at about SEK 10 160/month. Total cost per month per kg is estimated at SEK 10 160 per month and SEK 17.73 per kg. When investment costs are included the sum is SEK 18.40/kg. Security risks included a situation when young people took the light bulb and destroyed it outside the store. There were also thefts reported. The shop owner solved the problem by putting the wagon on a more clear sight. The purity of sorted waste is usually considered to be high (El-Kretsen, 2011).

Umeva model started in December 2009 as a joint program between El Kretsen and Umeva, a waste company of Umeå municipality. The custom made container was placed adjacent to shops, outdoors housing small WEEE, incandescent bulbs and CFLs. Investment costs depreciated over 10 years are estimated to be SEK 15 750/year. Operating expenses are estimated to be SEK 40 500/year. Total cost is estimated to be: SEK 14.65/kg. The cost is expected to decrease as quantities increase. Collection point was available 24 hours/day. Umeva had a land contract with municipality of Umeå and there was no need for additional environmental permits for these three facilities (El-Kretsen, 2011).

Finally El-Kretsen's report regarding alternative forms of waste collection states the following:

Those that are prepared to take waste to specified collection point usually chose those options that can be coordinated with other waste collection in public place, followed by collection in store. Relatively few choose libraries, municipal offices, bus stops and train stations possibly because there is no routine developed for waste disposal to these places (El-Kretsen, 2011).

3 Waste Collection Evaluation

Policy review showed that household waste collection was implemented mainly in the form of recycling, centers, curbside collection vehicle with fixed points and collections in store. Waste collection will now be evaluated by applying Triad model and findings from waste collection review.

ÅVC can be considered as a place with low proximity to households. According to Avfall Sverige (2011), development of additional collection with better accessibility should be considered for both incandescent light bulbs and CFLs. The fact that there are 650 ÅVCs with only several allocated in specific community, implies that there is certainly an important distance between collection point and households. The very infrastructure established by cooperation through between municipalities and producers demands additional residents' financial, time and physical investments in order to reach ÅVCs and discard GDL waste. Therefore level of opportunity factor associated with ÅVCs to reach desirable consumer behavior can be considered as low. Access to car is also needed which residents might not have. Residents may lack physical capability or necessary support to conduct a longer traveling. High awareness regarding possibility to discard GDLs in ÅVC exists mainly with the populations with established local residence due to experience and word of mouth. Residents that recently came to certain community might lack knowledge regarding ÅVCs. Since ÅVC does not increase awareness but rather requires additional information campaigns or residents' empirical learning, capacity level of ÅVC per se can be considered to be low. ÅVC usually requires time, includes expenses and demands activity which resident does not have to perceive as something worth the effort regarding small waste product such as GDL.

According to Darby and Obara (2005) there is a difference how consumers perceive small WEEE when compared to large WEEE. Unlike large WEEE, small WEEE is not problematic to the same extent due to its weight and size. Residents might be unwilling to invest available effort, money and time to dispose such a small item to a distant ÅVC. Therefore, motivation level can be considered as low.

Visiting ÅVC cannot generally be considered as a part of the usual established routines. Furthermore, routines regarding large WEEE disposal cannot be applied in this case because time for disposal does not have to correlate between small GDL waste and large WEEE. That is why residents often choose to store GDLs and wait to bring to ÅVC together with large WEEE. However, that means that bringing small WEEE is supplementary activity that occurs along with primary activity which is disposal of large WEEE. Therefore established routine factor regarding ÅVC for GDL waste disposal could be regarded as low.

Curbside collection offers high proximity to households. However, it also creates potential of environmental risk. Usually mentioned risks occur in the locked room in the property or in the red box. Highlighted risks regarding the storage of HW on the property include mixing of different HW when HW is left unattended, risks when the boxes stay at the property for long periods without being emptied and risks due to heavy lifting. A contact from Avfall Sverige confirmed that various sort of HW are put together into single box. Small WEEE including GDL is being placed next to the red box. Whether it is inside or outside the box, there is a potential of GDL to break resulting in mercury pollution. A number of municipalities require residents to check red boxes at the earliest, the night before the pick-up and that it must not stand out in the street but rather near the entrance or inside the property. Other municipalities require personal handover to avoid the risk of the waste being left unattended (Avfall Sverige, 2009). These safety risks can be regarded as something to be associated with the way the

system was established by the municipality. Therefore opportunity can still be regarded as low or as at least medium, since infrastructure is not necessarily meeting safety conditions as a prerequisite to participate in the collection system.

Residents usually cover the costs of curbside collection. These costs are expressed in the form of municipal charges which are specific and optional expense depending on whether the resident wants to use curbside service. Resident might decide to invest money and effort to reach ÅVC in certain time rather than paying for curbside collection. GDL can due to its small size makes it easier for resident to either store it until the proper time to visit ÅVC or discarded it in improper way. When personal handover applies, it can adversely affect the system's ease of usage because it requires that households agree on a specific time for a pick-up (Avfall Sverige, 2009). Costs, potential requirements to adjust as well as the above mentioned requirements to check the red box for security reasons may decrease resident's interest to use the curbside system. Therefore motivation factor regarding curbside collection system can be regarded as low, especially in the case when consumer can have an option not to participate.

Awareness of residents is usually high regarding curbside collection and due to proximity to household it can spread effectively. Furthermore car or high physical efforts are not required. Therefore, capacity level can be regarded as high. The issue of municipal charges can be considered as a capacity limitation especially because curbside collection might include costs for collecting other HW. However it can still be regarded as an issue that decreases motivation rather than a demand that the resident is incapable to meet. Therefore capacity factor could be regarded as high.

Curbside collection could be regarded as compatible with other established routines either because of other waste disposal or because waste could be thrown when going to conduct some other daily activity. Therefore routine factor could be regarded as high.

Collection through vehicles in fixed places with periodical mobility decreases the proximity to households. Therefore, opportunity can be regarded as high. Collected data could not specify whether resident had to cover the expenses through total municipal tax or optionally. The system requires that the vehicle with a relatively limited set up at a particular location, fits households needs. This additional requirement may be a contributing cause why the collected amounts in many cases did not reach expected levels (Avfall Sverige, 2009). Residents had to adjust their time to schedules of the vehicle which makes the system more demanding for residents. Therefore, the motivation factor could be regarded as low. Capacity factor could not be determined with certainty but could be assumed that it is high because access to car and high levels of effort are not required and there is a potential for knowledge increase. As with curbside collection, compatibility with established routes could also be regarded as high in this case.

Collection in store is at close proximity to homes. Furthermore, the high number of stores scattered around the populated area guarantee that most of area occupied by residents is covered. Therefore, opportunity factor could be regarded as high. It is hard to say anything at the moment regarding economic incentives or costs. However even in case that municipal tax resident might not experience this cost directly in relation to collection in store. On the other hand they will certainly have interest for easier disposal of waste GDL. Therefore motivation factor can be regarded as high. Access to car is not needed and frequent visit to retail stores increase the possibility of gaining knowledge about the collection. Therefore capacity could be regarded as high. Established routines present an especially compatible factor regarding disposal of GDL in store. This is especially true for grocery stores where residents go more

frequently for supplies or to dispose packaging waste when compared to specialized stores with electrical equipment. Therefore the routine factor could be regarded as high.

However, there is one addition to be made regarding former analyses. In each of these cases it is considered that municipalities are still paying the cost of waste collection. Therefore, it is actually the residents who are covering the expenses either through voluntary municipal charges or obligatory payments. Given the already high level charges and taxes that residents have to give for public spending in Sweden it is unlikely that residents would accept further increase in public financing to cover the expansion of waste collection system. In case of wider investments into household waste collection expenses will become higher as well. Potential opposition to higher municipal expenses could be considered as an expression of a low capacity factor for all collection forms because residents might not be capable to allocate additional incomes for public spending together with already existing financial obligations. However, the issue of obligatory general waste taxes may as well be interpreted as low motivation factor because residents might oppose to such public spending even if they could allocate additional funding. This kind of behavior might be also stimulated by the fact that producer responsibility is already reflected in higher product prices and that legally residents should dispose their GDLs free of charge as it will be discussed in further chapters. Therefore although general waste taxes are considered as an expression of low capacity factor alternative explanation might be low motivation factor.

The summary of the Triad model applied could be shown in Table 3-1.

Table 3-1 Waste collection evaluation

	Recycling center	Curbside collection	Vehicle with fixed site	Collection in store
Opportunity	Low	Low	High	High
Motivation	Low	Low	Low	High
Capacity	Low	Low	Low	Low
Established routines	Low	High	High	High
Total per collection form	Inconvenient	Inconvenient	Inconvenient	Convenient (experimental phase)
Total for entire system	Inconvenient			

The table includes altered capacity factor due to general waste taxation. Even if different interpretation is used, the general conclusion would be that each of the collection forms and collection system in general may be considered as inconvenient. The only exception is collection in store. However, since this system is still in experimental phase and already used systems are limited to certain communities and include safety risks (as shown in Chapter 2), it can be said that this potentials of collection in store do not change the general picture of the

current Swedish GDL household waste collection. Given the methodology applied, household waste GDL disposal convenience functions as an indicator for effective waste collection. It follows, that inconvenient waste collection system can be regarded as ineffective.

4 Policy Review

4.1 Historical Development

In order to investigate the existing waste collection policies regarding GDLs, it is important to understand the historical development of waste collection policies for GDLs. Moreover, it is important to identify the positions of relevant stakeholders during certain period of time. This research is relevant because it will lead to thorough understanding of how existing policies came to be, and what alternative policies might be created in the future. The historical review will cover the period before 2002. The reason is that in 2002 the EU Waste Electrical and Electronic Equipment Directive (WEEE Directive) was enacted while Swedish Ordinance SFS 2005:209 that transposed Directive was enacted in 2005. This legislation governs waste collection in Sweden until now.

4.1.1 Academic Research

A decrease in the incandescent lamp usage started to occur in the second half of the 20th century. A Study conducted by Mills (1991) explored the lighting sectors in 14 European countries, USA and Japan. Mills claimed that the sale of incandescent sources dropped from 90% in 1960 to 75% in 1990. Furthermore, global CFL sales reached 114 million in 1991. Lighting industry sources claimed that by the year 1995 sales would have exceeded 250 000 000 CFLs. Furthermore, Mills traced the beginning of wider implementation of GDLs in Europe back to the middle of 1986. Stockholm utility (Stockholm Energi) implemented first programs to increase energy efficiency in lighting sector. These projects were implemented as a part of demand side management (DSM), a strategy to lower the consumers' peak energy demand by increasing energy efficiency.

Mills's analysis (1991) included 42 programs conducted between late 1987 to the beginning 1990s. They were implemented in six European countries (including Sweden). The goal was to encourage the use of CFLs. These programs were based on financial incentives such as rebates, giveaways and wholesale discounts. The main targets were residential consumers. The main actors were manufacturers, utilities (Sweden) and governments (Germany & Netherlands). The total outcome was the introduction of 2 000 000 CFLs in residential areas. This outcome occurred either as a direct result of financial incentives or as an indirect result of a growing demand and associated cost decreases (Mills, 1991).

It can be seen that since the middle of 1980s, DSM started to create an outcome similar to the one associated with current phase-out policy. The growth of the GDL usage already raised some concerns among academic circles in the beginning of the 1990s. Mills (1991) addressed the importance of CFL waste collection and environmentally sound treatment. He suggested that a deposit-refund system should be established. However, Mills did not deliver any elaborated conclusions. He basically argued that the benefits of the wider CFL usage outweigh any drawbacks both from the perspectives of energy efficiency and mercury pollution. Strahl and Ryden (1995) expressed concerns that DSM projects did not consider end-of-life management of CFL to a necessary extent and suggested implementation of EPR on CFLs.

Another relevant study was conducted by Begley and Linderson (1991). Similar to Mills, they have also recognized the benefits of CFLs compared with incandescent bulbs regarding energy efficiency and life cycle mercury pollution. However, these authors were more worried about the harm mercury might pose from a rising CFL consumption during end-of-life phase. These concerns were especially related to studies that showed the potential environmental problems of mercury emissions during incineration and landfilling. Incineration releases 5% of mercury in gaseous form with the tendency to bind with other particles when cooled down. The rest of

mercury is captured in the form of fly ash. Further problems might occur when fly ash is landfilled due to less probability to stay in stable condition and higher possibility of leaching. Begley & Linderson research provided a limited amount of information regarding GDL waste collection and treatment. What they discovered was that in the beginning of 1990s, certain CFL separate collection & treatment existed. However, it was on the voluntary basis. The recycling of CFL waste has been conducted for over a decade. The share of the recycled mercury in all lamps discarded was estimated to be 30%. However, no data about the actual amount of lamps treated in environmentally effective way was provided. Here is how Begley & Linderson described the lamp collection based on the personal communication with officials from Sellberg AB and MRT System AB (subsidiary of Luma Lighting AB):

Customers collect the lamps themselves and deposit them into the containers sent to the compactors. We contacted various municipal utility and waste officials in Sweden responsible for collecting lamps and according to them, lamp breakage has not been a problem (Begley and Linderson, 1991).

Separately collected lamps were sent to Kvicksilver Återvinning AB (Mercury Recycling Inc.), a treatment facility in the city of Karlskrona. There the phosphorus part containing majority of used mercury has been separated. Through a process of distillation in a vacuum tower mercury is extracted while the rest of phosphor-mercury compound was sent to the national facility for handling of hazardous waste (SAKAB). Furthermore estimated costs for lamp collection and treatment at that time were estimated to be 5.5 SEK (USD 0.89) per lamp (Begley and Linderson, 1991).

Finally Begley & Linderson recognized the importance of a more organized approach towards separate and safe collection and treatment of GDLs. Author's recommendation for further development of the household waste collection were the following:

1. Deposit–refund system with recollection in retail shops, collection stations (near supermarkets, parking lots);
2. Specially located hazardous waste collection stations (near gas stations); and
3. Intermittent “household” collection (a spin-off of the curbside collection where once in several months a special vehicle establishes a temporary collection center near households and retail shops in order to collect stockpiled lamp waste).

Finally Begley & Linderson (1991) suggest the implementation of producer responsibility as a “alternative recycling concept”:

Having producers and suppliers be responsible for their product refuse can be looked at as a system of deposit (the product) and return (with the refuse) for business. It establishes a logical recycling link for both material (raw material - product - raw metal) and product (producer–customer-producer). The customer pays for the product and its recycling, the producers are made responsible for what they produce. This helps avoid excessive government involvement while requiring business to administer the system with free-market efficiency in order to keep the product price low. Such a system could be applied at retail stores, as well as in industrial and other locations.

4.1.2 Parliamentary Activities

During 1990s concerns in Sweden were raised by some members of the parliament (MOP) regarding GDL waste management.

In a motion 1990/91 named “For a good living environment” several members of the Left Party stated the following:

Municipalities should be required to account for recycling of fluorescent tubes, lamps etc. that contain mercury.

In a Motion 1990/91 called “Pledge of mercury lamps” Sven-Olof Petersson from the Center party, stated the following:

Worn out or discarded mercury-containing products are classified generally as hazardous materials under the regulation on chemical products. Lamps are an exemption. In Sweden about 16 000 000 fluorescent lamps, mercury lamps, and so called compact fluorescent lamps are being consumed every year. They contain a total of 75 kg of mercury. The problem is that there has been no one receiving hazardous waste of this kind before. For some time, MRT (Mercury recovery technology) in Karlskrona established itself as a recycler of mercury in fluorescent lamps. With reference to the foregoing proposals to parliament of the government request is given for a proposal for a deposit system for mercury-containing lamps and fluorescent lamps.

Similar request was stated again by the same MOP in a motion 1991/1992:

In Sweden, annually 16 000 000 of fluorescent lamps are consumed. These together contain about 600 kg of mercury. Unlike other products that contain mercury, and which after use are collected for disposal as hazardous waste, there is no satisfactory method today when it comes to collecting these fluorescent tubes and lamps in a good way to take advantage of their mercury content. The problem has previously been that it has been no appropriate system to solve it, but for some time, there is a system for doing so. This system is called MRT (Mercury Recovery Technology). Installations of this kind are in operation and in Karlskrona about 4 000 000 fluorescent tubes and lamps are taken each year for recycling.

Today, there are only recommendations regarding the collection and recycling of lamps/fluorescent lamps with mercury content. This means that only about 20-40% of these are collected and 60-70% of them end up in nature. To encourage the collection and recycling of the mercury, a deposit-refund system should be introduced at an early stage for fluorescent lamps/bulbs that contain mercury.

In a motion 1992/93 named “Disposal of fluorescent lamps” Rose-Marie Frebran (Christian Democratic Party) stated the following:

Mercury lamps and fluorescent lamps have not been regulated as hazardous waste in Sweden so far. This means that in principle, it is permissible to dispose of this hazardous waste in an ordinary way. So you throw the lamps into the garbage. It is possible to separate the mercury in these lamps and fluorescent tubes and then recycle it.

The collection of mercury-containing lamps and fluorescent lamps is unfortunately not running smoothly. Since the lamp is not classified as hazardous and there are no landfill bans, there are many companies reluctant to pay for the safe handling. It is not rational to solve the problem with the decision of a landfill ban in each municipality across the country. A more simple solution involves classification of mercury-containing lamps and fluorescent lamps as hazardous waste.

In a motion 1992/93 Sven-Olof Petesson once again called for an establishment of a deposit-refund system:

In Sweden about 16 000 000 fluorescent lamps, and so called compact fluorescent lamps are consumed annually. These together contain about 600 kg of mercury. Unlike other products that contain mercury, and which after use are collected for disposal as hazardous waste, there is no way today when it comes to collecting these fluorescent tubes and lamps in a good way to take advantage of their mercury content. The problem has previously been that there has not been an appropriate system to solve this issue, but for some time, there is such a system. The system is called MRT (Mercury Recovery Technology). Installation of this kind is in operation and in Karlskrona each year about 4 000 000 fluorescent tubes and lamps are taken for recycling.

Today there are only recommendations regarding the collection and recycling of fluorescent lamps with mercury content. This means that only about 30-40% of these are utilized and 60-70% of them are ending up in nature. To encourage collection and recycling of the mercury, a deposit-refund system for fluorescent lamps/ bulbs should be introduced at an earlier stage. I think it is important that the Environmental Protection Agency be mandated to urgently develop such a deposit system.

The same request from the before mentioned MOP occurred in motion 1993/94:

For the individual it is only a small number of items that they come in contact with mercury. The most common product would be fluorescent lamps, or other types of lamps. In the case of fluorescent tubes/ bulbs with mercury content, it is only 30-40% of those treated in an environmentally sound manner. The remaining 60-70% comes out among other waste and spread in nature. Therefore, it is important that the collection of these products is stimulated. This should in my opinion be accomplished by establishing a deposit system for these light sources.

In a motion 2007/08 Christin Hagberg from the Social Democratic party stated the following:

Parliament announces to the Government its opinion as outlined in the motion that the collection of the used light bulbs and CFLs should increase.

Light bulbs and CFLs contain substances that are good neither for man, animals or nature. Moreover, it is possible to leave them in recycling centers but for different reasons, they might end up with the majority of household waste.

Municipalities have a responsibility to inform as to how waste is managed in the local community and should provide more and better information for household on this issue. The responsibility for these light sources to be collected is left to producers, but they have not seriously taken hold of the problem. It is good that there is a possibility to dispose light sources to the recycling centers, but it must be considerably easier to leave in a place that has high availability. It should be possible to coordinate with those who sell the lamps, i.e. business, to also collect them when they are exhausted.

4.1.3 Swedish WEEE Ordinance SFS 2000:208

Swedish Ordinance SFS 2000:208 on Producer Responsibility for Electronic and Electrical Waste was enacted on April 6, 2000. This law introduced producer responsibility for WEEE in Sweden before the EU WEEE Directive was enacted. The Ordinance did not fully meet the requirements of the EU WEEE Directive, which was the reason it had to be changed afterwards. Except for producer responsibility, the Ordinance introduced new legal requirements regarding collection and treatment of WEEE. After the transposition of the WEEE Directive the Ordinance SFS 2000:208 continued to be used, however, only for incandescent light bulbs. The reason is that incandescent light bulbs were not included in equipment covered by the WEEE Directive. The following text will present the parts of the Ordinance considered to be relevant for GDL waste collection.

4.1.3.1 General Provisions

General Provisions of the Ordinance contain the following:

(1) This regulation contains provisions regarding producers' obligation to deal with waste consisting of electronic and electrical products, provide information on their responsibility concerning products and to consult about obligations regarding performance.

(3) The term "producer" in this Ordinance refers to manufacturers, importers and distributors of the electrical and electronic equipment.

4.1.3.2 Responsibility to Take Care of the Electronic and Electrical Equipment

This part of the Ordinance contains the following provisions:

(5) A producer shall, without compensation, receive an electronic and electrical equipment if

- 1. Returned to the producer when the producer sells an electronic and electrical equipment, and,*
- 2. In normal use fulfill essentially the same function as the sold product.*

This duty to accommodate refers to the products of each sale and the same number of products covered by sales.

(6) If the product is sold by the producer the provisions in article 5 shall apply only if the product being sold has not been previously sold (author's comment: before this law) by the producer in Sweden.

(7) The producer shall fulfill its obligation under article 5 where the producer delivers the product sold.

(8) The producer may even fulfill obligations under the article 7 by providing a suitable location where electronic and electrical equipment is received on the producer's behalf.

A reception is considered suitable if:

Manufacturer or the person hired has consulted with the municipality regarding carrying out the obligations in accordance with article 7, and,

Site is suitable from both the consumer and environmental point provided that the consultation regarding conditions is reached with the municipality.

(9) The producer shall ensure that the products received by the producer or by someone hired by the producer are reused, recycled or disposed in an environmentally acceptable way.

Several rules can be derived from stated provisions:

- Producers are responsible to accept WEEE on 1:1 basis;
- Producers are responsible to accept WEEE without compensation;
- Producer shall fulfill his obligation where the sold product is delivered, or, optionally setting other suitable location for WEEE reception after consultation with the municipality;
- Producer is responsible for WEEE being reused, recycled or disposed in environmentally acceptable way; and
- Producer responsibility is limited to products sold after the adoption of the Ordinance, implying that responsibility for collection & treatment of historical products remains within municipal responsibility.

4.1.3.3 Duty to consult with the municipality

This part of the ordinance sets the following provisions:

(13) If an affected municipality requests, the producer shall consult with municipality how the obligations from articles 5-8 and 10 are going to be fulfilled.

An eligible municipality means a municipality in which the obligation to take care of the products shall be accomplished according to article 7.

A consultation will aim at taking into account the local conditions in municipality in order to find practical ways to coordinate producer responsibility under this regulation with the municipal waste regulation.

(14) The producer shall be considered to have fulfilled his obligation to consult if

1. Municipality provided a detailed account of how the producer fulfills or intends to fulfill the obligations arising from articles 5-8 and 10, and,

2. The municipality is given the opportunity to confer with the producer regarding changes or the coordination the municipality considers necessary.

4.2 Existing Waste Collection Policy

4.2.1 EU WEEE Directive

The EC Directive 2002/96/EC on waste electrical and electronic equipment (WEEE) was enacted on 2002. It establishes the rules for waste management of WEEE in the EU. The objectives of the Directive were defined under Article 1 and are stated as follows:

The purpose of this Directive is, as a first priority, the prevention of waste electrical and electronic equipment (WEEE), and in addition, the reuse, recycling and other forms of recovery of such wastes so as to reduce the disposal of waste. It also seeks to improve the environmental performance of all operators involved in the life cycle of electrical and electronic equipment, e.g. producers, distributors and consumers and in particular those operators directly involved in the treatment of waste electrical and electronic equipment.

The importance of the WEEE Directive for GDL waste collection is that these lamps are classified as WEEE under the Directive. Therefore, the WEEE Directive affects the waste collection of GDLs. Although the WEEE Directive contains multiple complex features, the following analysis will focus on the presentation of the sections relevant for GDL household waste collection.

4.2.1.1 WEEE Directive and the Principle of Producer Responsibility

The cornerstone principle behind the WEEE Directive was the principle of Producer responsibility. It is provided under the several recitals of the preamble:

*(5) The European Parliament, in its Resolution of 14 November 1996 (7), asked the Commission to present proposals for Directives on a number of priority waste streams, including electrical and electronic waste, and to base such proposals on **the principle of producer responsibility**.*

*(12) The establishment, by this Directive, of **producer responsibility** is one of the means of encouraging the design and production of electrical and electronic equipment which take into full account and facilitate their repair, possible upgrading, reuse, disassembly and recycling. (19) Basic principles with regard to the financing of WEEE management have to be set at Community level and financing schemes have to contribute to high collection rates as well as to the implementation of **the principle of producer responsibility**. 20) In order to give maximum effect to **the concept of producer responsibility**, each producer should be responsible for financing the management of the waste from his own products.*

It can be seen that separate waste collection is not explicitly connected with the producer responsibility principle. However, the principle is connected with financial responsibility of producer to manage waste from product manufactured. Therefore, responsibility for collection is implied at least regarding financing.

4.2.1.2 Definition of Light Sources

The Article 2 of the Directive states the following:

1. This Directive shall apply to electrical and electronic equipment falling under the categories set out in Annex IA provided that the equipment concerned is not part of another type of equipment that does not fall within the scope of this Directive. Annex IB contains a list of products which fall under the categories set out in Annex IA.

Product categories set out in Annex IA include the following:

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

Annex IB category 5 “Lighting equipment” includes following products:

1. Luminaires for fluorescent lamps with the exception of luminaires in households;
2. Straight fluorescent lamps;
3. Compact fluorescent lamps;
4. High intensity discharge lamps, including pressure sodium lamps and metal halide lamps;
5. Low pressure sodium lamps; and
6. Other lighting or equipment for the purpose of spreading or controlling light with the exception of filament bulbs.

4.2.1.3 Separate Collection

Under Article 5, the WEEE Directive states the following:

1. Member States shall adopt appropriate measures in order to minimise the disposal of WEEE as unsorted municipal waste and to achieve a high level of separate collection of WEEE.

2. for WEEE from private households, Member States shall ensure that by the 13 August 2005:

(a) systems are set up allowing final holders and distributors to return such waste at least free of charge. Member States shall ensure the availability and accessibility of the necessary collection facilities, taking into account in particular the population density;

(b) when supplying a new product, distributors shall be responsible for ensuring that such waste can be returned to the distributor at least 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. Member States may depart from this provision provided they ensure that returning the WEEE is not thereby made more difficult for the final holder and provided that these systems remain free of charge for the final holder. Member States making use of this provision shall inform the Commission thereof;

(c) without prejudice to the provisions of (a) and (b), producers are allowed to set up and operate individual and/or collective take-back systems for WEEE from private households provided that these are in line with the objectives of this Directive.

5. without prejudice to paragraph 1, Member States shall ensure that by 31 December 2006 at the latest a rate of separate collection of at least four kilograms on average per inhabitant per year of WEEE from private households is achieved.

Therefore Article 5 established several important rules:

- Member states shall “adopt appropriate measures” to increase separate collection;
- MS should “ensure” consumers should be capable of returning their WEEE free of charge;
- Distributors are responsible to accept WEEE from consumers based on 1:1 rule; MS may depart from this provision if it does not endanger the convenience for consumers;
- Producers can optionally choose to operate take - back systems for private households’ WEEE;
- Producers can operate take - back systems either individually or collectively; and
- Each Member state is obliged to reach WEEE collection of at least 4 kg /per capita/ annually for private households.

4.2.1.4 Financial Responsibility for Collection

Article 8 states the following:

1. Member States shall ensure that, by 13 August 2005, producers provide at least for the financing of the collection, treatment, recovery and environmentally sound disposal of WEEE from private households deposited at collection facilities, set up under Article 5(2).

2. For products put on the market later than 13 August 2005, each producer shall be responsible for financing the operations referred to in paragraph 1 relating to the waste from his own products. The producer can choose to fulfill this obligation either individually or by joining a collective scheme.

3. The responsibility for the financing of the costs of the management of WEEE from products put on the market before the date referred to in paragraph 1 (historical waste) shall be provided by one or more systems to which all producers, existing on the market when the respective costs occur, contribute proportionately, e.g. in proportion to their respective share of the market by type of equipment. Member States shall ensure that for a transitional period of eight years (10 years for category 1 of Annex IA) after entry into force of this Directive, producers are allowed to show purchasers, at the time of sale of new products, the costs of collection, treatment and disposal in an environmentally sound way. The costs mentioned shall not exceed the actual costs incurred. Member States shall ensure that each producer provides a guarantee when placing a product on the market showing that the management of all WEEE will be financed and that producers clearly mark their products in accordance with Article 11(2). This guarantee shall ensure that the operations referred to in paragraph 1 relating to this product will be financed. The guarantee may take the form of participation by the producer in appropriate schemes for the financing of the management of WEEE, a recycling insurance or a blocked bank account.

Therefore Article 8 established the following rules:

- MS shall ensure that producers provide “at least” for the financing of the collection of WEEE from private households deposited at collection facilities;
- Producers shall be responsible for financing the waste collection of their own products;
- Producers can fulfill collection requirements either individually or by joining the collective scheme;
- Products put on market before 13 August 2005 (“historical” waste) shall be collected through collective financial schemes;
- For 10 years after the adoption of the Directive the producers are allowed to state the price of recycling (“visible price”) for “historical” WEEE; and
- MS shall ensure that producers provide a financial guarantee for new waste by participating in appropriate schemes for the financing the WEEE management, a recycling scheme or a blocked bank account.

4.2.2 Swedish Ordinance SFS 2005:209

The Ordinance SFS 2005:209 is a legislation that sets the rules for waste collection of GDLs in Sweden. This section will provide the review of provisions relevant for GDL waste collection. It was also a way in which Sweden transposed the EU Directive on waste electrical and electronic equipment (WEEE Directive).

4.2.2.1 Purpose of the Ordinance

The exact purpose of the Ordinance was defined as follows:

Section 1. The purpose of this Ordinance is to ensure that electrical and electronic products are designed and manufactured in a way that prevents waste and, in the case of waste that is nevertheless generated, that:

- 1. producers shall provide systems for collection of the waste,*
- 2. the products can be re-used or recycled, and*
- 3. the targets set out in Annex 3 to this Ordinance are achieved.*

4.2.2.2 Scope

Under the chapter “Scope” the following was stated:

Section 6. This ordinance shall apply to the electrical and electronic products set out in Annex 1 of the Ordinance.

Annex 1 includes GDLs.

4.2.2.3 Obligation to Deal with Products

Under the chapter “Obligation to deal with products” the following was stated:

Section 12. A producer shall deal with waste electrical and electronic products if, after 12 August 2005, the producer has sold the products in Sweden or in another Member State of the European Union or at a distance to such a Member State.

Section 13. A producer shall participate in action to deal with waste electrical and electronic products put on the market before 13 August 2005 that become household waste.

Section 15. *The producer shall deal free of charge with waste referred to in Sections 12–14 that has been generated by households.*

Section 16. *For waste that can be expected to be generated in Sweden a producer shall fulfill his obligation under Sections 12–14 by ensuring that:*

1. there are one or more appropriate collection systems for waste referred to in Sections 12 and 13

Section 17. *A collection system shall be regarded as appropriate if:*

1. it is easily accessible and provides good service to households, municipalities and other users who can be expected to want to deliver the electrical and electronic products referred to in Sections 12 and 13,

2. it makes it easier for households and other users to sort the products from other waste,

3. for waste referred to in Section 12 there are collection systems with an appropriate geographic spread in view of the expected use and service life of the products sold and other circumstances,

4. for waste referred to in Section 13 there are collection systems in every municipality,

5. as regards household waste it means that products of the same product type as the products for which the collection system is intended can be delivered to the system even though the producer's responsibility to deal with waste is limited to certain products or a certain share of the waste generated,

6. it promotes the reuse of all or part of the product, and

7. it is designed so that persons managing the products in the system are not exposed to health and safety risks due to the nature of the products.

In the assessment of what is to be regarded as an appropriate collection system, special account shall be taken of what has emerged at consultations between the municipality and the producer under Section 23. For service to municipalities under the first paragraph, point 1, the collection system shall enable products to be delivered to the system or to be collected by someone representing the system at least at the place or one of the places arranged by the municipality concerned for the management of waste electrical and electronic products. The municipality and the producer may agree on deviations from this requirement.

Therefore this chapter established several rules:

- The producer shall ensure that there is at least one established WEEE collection system;
- Producers shall establish the collection system free of charge;
- Producer must consult with the municipality concerning what will be regarded as appropriate collection system;
- At least one collection point for the collection system must be arranged in accordance with the municipality;
- The producer is responsible for WEEE put on market before the ordinance was enacted (“historical WEEE”); and
- The collection system shall be regarded as appropriate if convenience for consumers and product reuse are assured.

Legal provisions explaining the relationship between municipality and producer are given in chapter “Consultation”. Therefore, it is logical to include the presentation of the chapter at this point.

4.2.2.4 Consultation with Municipalities

This chapter states the following:

Section 23. *A producer who is required to provide a collection system under Section 16 shall, as regards household waste consisting of electrical and electronic products, consult every municipality concerned on matters regarding the collection system. The purpose of this consultation shall be to coordinate the producer’s responsibility with the municipality’s refuse collection duty in the light of local conditions in the municipality.*

Section 24. *The producer shall fulfill his consultation obligation before the collection system is brought into use or otherwise when requested by the municipality by:*

1. *supplying the municipality with a detailed account of how the producer is fulfilling or intends to fulfil the obligations that follow from Section 17,*
2. *supplying to the municipality the data that the municipality needs in order to be able to inform households under Section 21 as well as the other data about the handling of electrical and electronic products that are needed for the municipality’s refuse collection system, and*
3. *giving the municipality the opportunity to hold discussions with the producer on the alterations or the coordination that the municipality considers necessary.*

Therefore this chapter provided several important rules:

- Producer shall consult with the municipality regarding WEEE collection with to municipality’s refuse collection duty;
- Producer shall provide data that necessary for municipality to inform households regarding WEEE collection; and
- Producer shall give municipality the opportunity to consult with the producer.

4.2.2.5 Financial Obligations

Under the chapter “Obligation to ensure financing for the fulfillment of the producer responsibility” the following was stated:

Section 18. *A producer who sells electrical and electronic equipment in Sweden or at a distance to another Member State of the European Union shall ensure through a financing system, insurance arrangements, blocked accounts or in some other appropriate means that financing is available for the fulfillment of the producer’s obligation to deal with products under Section 12 read together with Section 16 even if the producer terminates his operations or fails to carry through on fulfillment for some other reason.*

Action to ensure fulfillment shall be regarded as appropriate if it is likely, in view of the expected use and service life of the product sold and other circumstances, that the obligations will be fulfilled or that the person who fulfils the producer’s obligations can obtain compensation for the costs that fulfillment will entail.

Therefore, this chapter provides following important rules:

- Producer’s financial responsibility to deal with WEEE; and

- Producer's responsibility to provide financial guarantee for new WEEE in case the producer ceases to exist in future.

4.2.3 Other Legislation

Although Ordinance SFS 2005:209 sets the main rules two additional legal acts also govern or helps to understand the Swedish waste collection. First, Swedish Environmental Code from 1998 under Chapter 15 section 8 prescribes the general municipal responsibility for household waste:

Unless other provision is made pursuant to section 6, (concerning general producer responsibility framework) municipalities shall ensure that:

Household waste generated in the municipality is transported to a waste treatment plant where necessary in order to protect human health and the environment and safeguard private interests.

Second, Waste Ordinance SFS 2011:927 includes certain provisions regarding residents' responsibility. Under the chapter "Electrical and Electronic Product" the Ordinance states the following:

25. The holder of waste consisting of or containing waste electrical and electronic products shall:

- 1. Sort out the electronic and electrical products and manage them separate from other waste, and,*
- 2. Manage the electrical and electronic products in a manner that promotes reuse of all or parts of the devices, and otherwise facilitate recycling or handling acceptable from an environmental standpoint.*

The Ordinance SFS 2011 inherited these provisions from the Waste Ordinance SFS 2001:1063.

Finally, it should be noted that littering is also forbidden under the rules dating back to the Nature Conservancy Act from 1964.

4.2.4 Stakeholders' Debate

In a document "Frequently asked question about the household appliance industry's appraisal of Directive 2002/96/EC on WEEE" European Committee on Domestic Equipment Manufacturers (CECED) objected on the idea that collection costs should mainly be shifted on producers. First argument was that prices might potentially increase on a high level. Second argument was that producers would have difficulties to control how municipalities are using the funding provided by producers, provided that municipalities keep the control over the collection infrastructure (CECED, 2004). In 2006 Council of European Municipalities and Regions (CEMR) expressed different concerns that unclear definition of responsibilities under the WEEE Directive regarding household collection may result in costs been shifted to local authorities (CEMR, 2006). In a study conducted under EU Directorate General Environment an opinion was given that the provision that the producer finance collection at least from local collection facilities opened the possibility for States to expand producer responsibility to include household collection (HIEE *et al*, 2007).

Main NGO opinions of the EU environmental policy related to GDL waste were expressed in the work of an EU environmental NGO cooperation "European Environmental Bureau" (EEB).

In March 2008 a joint position paper by several NGOs (ECOS, EEB, ZMWG, CAN-Europe, INFORSE-Europe, Greenpeace and WWF) was released regarding EC Working Document on possible Ecodesign requirements for general equipment. This working document was prepared after the Ecodesign Directive was enacted and prior to Regulation 244/09. NGOs expressed their concern about the waste of GDLs in the context of incandescent bulb phase out. Environmental NGOs also advocated for the phase out to speed-up the implementation of the separate collection and recycling chains for CFLs everywhere in the EU. With the phase out of incandescent bulbs and halogens, the issue of proper collection and treatment of GDLs would become crucial to ensure a high level of mercury recovery. Therefore, this aspect should be better covered by the WEEE Directive (ECOS, 2008).

Shortly afterwards, in June 2008, EEB and Zero Mercury Working Group (ZMWG) organized a conference named “Mercury Containing Lamps under the Spotlight” and the conference report was published in December, the same year. European Commission (EC) representatives, several NGOs, business organizations and professional associations participated in a conference debate.

EC representatives shortly acknowledged the fact that not enough information was provided to consumers regarding the need to sort GDL waste. EC also emphasized the need to recover the mercury in lamps, however “without over-regulating the market” (EEB, 2008).

NGOs also criticized the current WEEE Directive regarding established collection targets because of the two reasons. First, the collection target of 4 kg was too low in the case of lamps. Second, established targets are unified and based on weight which means that there are limited incentives for the waste management organizations to collect lamps due to its lower weight (EEB, 2008).

Philips on the other hand had the position that the WEEE Directive should rather be implemented appropriately than changed. Philips commented NGOs standpoint on collection targets saying the focus should not be on targets. The reason is that the organizations responsible for waste collection will focus on the targets instead of trying to use their potential to the fullest extent (EEB, 2008).

Philips commented on high recycling costs by that collection and recycling costs are almost the same as production costs and not the retail sales costs; typically EUR 0.25 to 0.60 compared with EUR 1 for retail lamps (EEB, 2008).

Osram acknowledged the importance of the issue that low collection rates and collection rate disparities across EU presents (EEB, 2008).

Unlike other participants, Professional Lighting Designers Association (PLDA) brought into question the positive outcome of the phase out policy partially because of the difficulty in waste collection:

2 100 000 000 incandescent lamps are sold each year in Europe which equates 350 000 000 CFLs assuming that on average they last 6000h per life. At the same time this means as many CFLs will be disposed every year because of the difficulty to persuade the public to recycle unfortunately often those CFLs end up in landfills which is the worst method of disposal. Once the lamp is there, microbes will transform mercury to methyl mercury which is 20 times more toxic than metallic mercury (EEBH, 2008).

The overall conclusion stated by EEB and ZMWG after the conference was the following:

It is expected that the EU will move to phase out of incandescent lamps over the next several years. As a result, there will be an enormous increase in the number of lamps containing mercury, and even more mercury will be put into circulation if steps are not taken to further reduce mercury content and require best practices for those lamps manufactured and/or used in EU. Furthermore separate collection of such lamps becomes even more important because of the hazardous content and their fragility (EEB, 2008).

In 2009 EEB published a position paper named “EEB Position Paper on the Proposal for the Revision of the Directive on Waste Electrical and Electronic Equipment”, EEB criticized WEEE Directive regarding established target since it actually gives priority to heavier WEEE collection over small WEEE. EEB recommended that for each different product group separate collection targets should be introduced instead of an existing common weight based system. Furthermore, the following was stated:

Separate sub-categorized, product-specific targets, at least for light appliances and lighting equipment, are therefore essential to avoid such products being disposed of in municipal waste and reducing negative impacts on the environment and human health. For example light appliances such as compact fluorescent lamps have significant environmental impacts despite low overall weight and are more likely to end up in the municipal stream if not specifically addressed (EEB, 2009).

Except for the information acquired through the mentioned EEB conference, lamp producers delivered their positions through EU association “European Light Companies Federation” (ELCF).

In a blueprint “Let there be Light” from 2006, ELCF called for changes in the way the WEEE Directive was being implemented in the case of the light sector. The main claim was that the light sector has some specific feature when compared with other WEEE. These specific features are the following:

1. Recycling cost vs energy efficiency. The cost of the collection and treatment of energy efficient lamps are high and not profitable for producers even if they manage to recover valuable materials. ELCF estimates the cost of recycling at this point to be around 60% and in some cases even 80% of the current retail prices. ELCF warns about the possibility that under current WEEE Directive rules retail prices of energy efficient lamps may be even 4 times higher than production (cost) price depending on price adding through the selling chain. Sweden was cited as the best example where sales prices increase 50%;
2. Volume vs tonnage. Lamps are also specific because of their low weight per unit while at the same time the volume of their share in the EEE market is high. WEEE Directive defines the common targets for all WEEE to be 4 kg/capita/year. An organization responsible for collection is therefore incentivized to collect heavier WEEE. ELCF referred to the case of Germany:

WEEE sold in Germany in a given year amounts for 122 million pieces and came to a combined weight of 24 400 tonnes – 1 tonne therefore corresponds to 5000 WEEE lamps. By contrast, one can observe that 15.5 million units of white goods are sold in Germany in the same year amounting to 760 000 tonnes – 1 tonne corresponding to approximately 21 units. Hence, for the same weight, 250 times more lamps have to be collected than for white goods.

ELCF concluded that an estimate that in Germany lamps account for less than 1% by weight of the stream versus more than 80% of the unit quantities were counted (ELCF, 2006).

Furthermore, it was suggested that cooperation between municipalities and PROs should be created where municipalities would collect from household to collection point while PROs would collect from collection point onwards. Swedish collection system was proposed to serve as a model for other EU member states. The given reason was that Swedish collection efficiency equaled 80% collection rate (ELCF, 2006).

In “Questions and answers on the EU decision to phase out incandescent and less energy efficient lamps” of March 2009, ELCF stated the following:

Under the EU WEEE Directive, the European lighting industry has set up over the last few years a Europe-wide recycling infrastructure, which aims to achieve an 80% recycling rate of energy saving fluorescent lamps. These lamps are typically used for 10 years and we are confident that the recycling system will be fully operational by the time these get at the end of their life (ELCF, 2009).

In 2011 a Swedish newspaper Svenska Dagbladet (SvD) conducted an investigation regarding mercury pollution from unsorted CFLs. SvD published results from Swedish Glass Recycling Association (SGÅ) that annually 200 000 CFLs are discarded into glass. SvD reported that in March 2010 El-Kretsen met with SGÅ representatives to discuss problems regarding CFL recycling and that according to SGÅ “a consensus has been made regarding seriousness of the situation”. CEO of SGÅ Frank Tholfsson also stated that SGÅ’s concerns were raised after the phase out of the incandescent bulbs began. SGÅ also reiterated its concerns in several short reports (SvD, 2011).

Furthermore, SvD interviewed Minna Gillberg, environmental expert and former advisor of Margot Wallström, during her time as an EU Commissioner for Environment. Gillberg stated the following:

The environmental benefits talked about here are really intended for political advantage. From this perspective, environmental benefits of phase out become rather a symbolic expression of a climate policy that does not actually benefit the environment or human health. It is dangerous and irresponsible how this (phase out) was handled. There is no automatic recovery system, and no collection statistics. Decades were devoted for clearing Sweden from mercury, only to have it spread out again, completely out of control. It is absolutely ridiculous (SvD, 2011).

It was not possible to acquire further information from SGÅ regarding their estimation of the amount of CFLs put into glass. Moreover several contacts from municipal sector and Avfall Sverige disputed the figures SGÅ gave to the public, in order to mobilize support. However, even if SGÅ’s claims are exaggerated, this does not exclude the fact that certain amounts of CFLs are being thrown into glass and that SGÅ is having difficulties in dealing with them including a need to catch public attention.

Swedish NGO “Naturskyddsföreningen”, or “Swedish Society for Nature Conservation” (SSNC) published an online report in 2011 in which concerns regarding 200 000 disposed CFLs in glass were reiterated. Furthermore, Svante Axelsson, Secretary General of the SSNC stated the following:

It is unacceptable to spread the mercury into the environment and, therefore, should be subject to a number of instruments. In order for these lamps to be collected properly, first of all, there should be well established collection points with appropriate containers. People put CFL in glass in the absence of anything else (author’s statement: meaning, collection points). As with the aluminium cans, SSNC believes that producer responsibility (regarding collection) and deposit system on lamps should be introduced. It is a powerful and proven way to stop the cycles of waste (Naturskyddsföreningen, 2011).

4.3 Policy Implementation

After the introduction of the Waste Ordinance on Producer Responsibility for Electrical and Electronic Products from 2000, the lighting industry established a producer responsibility organization (PRO) with the purpose of providing collection and treatment of WEEE. Initially, the responsibility was to cover new products. However, in reality an agreement was signed between El-Kretsen representing producers and Swedish association for municipal management called “Avfall Sverige”, representing municipalities on the other side.

Both producers and municipalities had an interest to alter the responsibilities initially envisioned by law. Municipalities wanted to regain responsibility over total collection within municipality, including WEEE from new products (after the adoption of the Ordinance). On the other hand, municipalities were neither experienced nor interested in treatment process regarding historical products. Furthermore, municipalities intended to also keep informative responsibility. Producers were not willing to take the burden regarding collection of new products within municipalities. On the other hand, they were willing to take responsibility for treating all WEEE, hence, including the one made before the Ordinance adoption.

The outcome was the agreement in which municipalities kept physical and financial responsibility for collecting WEEE from households including costs for operating municipal collection points (EPA, 2011). Producers became physically and financially responsible for collection of WEEE from municipal collection points and subsequent treatment and financially responsible for collection containers (IIIIEE, 2007). Household WEEE was first either brought by municipalities or by residents themselves to municipal collection points. These collection points were usually in the form of large collection centers (ÅVC) maintained by municipality or associated contractor, while El Kretsen or associated contractor would collect the waste from the collection point onwards. This kind of cooperation between municipalities and El-Kretsen was called “El-Retur”.

Adoption of the new Ordinance 2005:209 basically did not change this cooperation. The only main difference was that producers were not obliged to accept WEEE based on 1:1 rule. This change faced important opposition from the retailers since under the new Ordinance they were not included under the category of producers (IIIIEE, 2007). However, what actually caused change according to contact from Avfall Sverige, was the change in market price of the materials used in EEE. This meant that El-Kretsen started to experience benefit from the treatment process while the collection costs for municipalities continued to increase. Therefore, Avfall Sverige started to demand greater financial share of producers for collecting and informing. On the other hand municipalities wanted to keep physical infrastructure for collecting and informing. What resulted was the series of negotiations after which a compromise would be achieved regarding financing. For example in 2009 agreement was achieved that El Kretsen will pay SEK 37 000 000 per year. The initial offer of El-Kretsen was SEK 13 000 000 while Avfall Sverige initially requested SEK 50 000 000. However, until now, responsibility for household collection still predominantly rests upon municipalities.

After the SvD published the figure of 200 000 CFLs discarded into glass Swedish Government, more specifically, Swedish Minister of Environment, Lena Ek became increasingly interested in the topic. In 2012 the agreement reached between the Government, and waste management actors that during 2012 2 000 000 more CFLs are to be collected. However, except for increasing informing campaign no details were presented to the public regarding further GDL waste collection improvements (SvD, 2012). According to Avfall Sverige contact current political atmosphere with the Government strengthens the position of Avfall Sverige during upcoming negotiations with El-Kretsen regarding share of financial responsibility for WEEE household collection.

5 Policy Analysis

5.1 Current Policy

The WEEE collection targets set under the WEEE Directive were based on the total collection of WEEE estimated in weight. Sweden transposed the targets in the same way. This kind of target formulation had several undesired outcomes regarding GDL waste collection.

First, formulated target decreased the relevance of collection rate as an indicator of GDL collection effectiveness. The target achievement could be determined by measuring the weight of the entire WEEE collected per year. There were no incentives to legally establish common methodology for calculating the collection rate either in Sweden or EU in general. Therefore, target formulation contributed to present difficulties in determining GDL waste collection rate.

Second, focus of the entire waste collection was given on the collection of entire WEEE. This implies that the targets could be accomplished even if the specific collection of GDLs is not on high level.

Third, establishment of targets based on weight further decreased the importance of GDL waste collection. The reason is that GDL is a category of WEEE considered much lighter and smaller than other types of WEEE (TVs, freezers etc.). The targets could be achieved by focusing on heavier WEEE which is also more difficult for residents to dispose. Residents would be willing to invest time, effort and money to drive to ÅVC to discard their WEEE especially, heavier categories. The WEEE disposed would be sufficient to meet the required targets.

Therefore ÅVCs as a main waste collection form served the purpose of achieving stated targets. The possibility that specific features of residents' disposal behavior of waste GDLs had less relevance from the perspective of the stated targets. There were limited incentives for the establishment of collection in stores, or more effective and safer curbside collection for GDLs. These collection forms would increase the costs and organizational efforts without significantly increasing the stated targets.

Ordinance SFS 2005:209 transposed the EU WEEE Directive in such a way that it established physical responsibility for producer to establish collection points for WEEE where residents could return WEEE free of charge. The Ordinance was more exact regarding producer's physical responsibility. The EU WEEE Directive only established responsibility for Member States to establish WEEE collection while producer physical responsibility was optional. The Ordinance SFS 2005:209 also included the provision that producers should consult with the municipality regarding appropriate collection sites. During the establishment of the collection system it should be considered that municipalities traditionally operated waste collection with already established interests. On the other hand, producers were not interested in waste collection from households due to the associated collection costs.

Ordinance SFS 2005:209 established financial responsibility through transposition. However, since the financial responsibility was not specified in the Ordinance SFS 2005:209, and the WEEE Directive left the collection of WEEE from households as an optional matter, there was enough space to amend producer financial responsibility during the establishment of the waste collection. As presented in Chapter 3 IIIIEE *et al* report (2007) indicated that financial responsibility specified under WEEE Directive to finance collection at least from the collection points, gives Member states to expenad responsibility to household collection.

However, Member states also got a possibility not to expand financial responsibility or to define it in such a way so it can be amended in practical establishment of the waste collection.

WEEE Directive's optional provision for Member States to include distributor responsibility to accept WEEE based on 1:1 rule was not included in the Ordinance SFS 2005:209. Sweden chose the possibility given under the WEEE Directive to opt against the transposition of distributor responsibility, although under the previous Ordinance SFS 2000:208, distributors were included in the concept of producer.

Formulation of the Ordinance 2005:209 gave space to producers and municipalities to establish the cooperation in which municipalities would be mainly be responsible for household collection while producers would be responsible for collecting WEEE from local collection points and transporting it to treatment facilities. These collection points are ÅVCs.

Lack of provisions regarding distributor responsibility decreased the possibility for distributors to actively participate in household collection. The exemption is voluntary commitment and paying for GDL storage, as is the case with previously described Collector in store.

It should be noted that the Ordinance 2000:208 had certain potential to establish collection in store. The reason is that producer had to accept WEEE when new EEE was sold. This might have stimulated producers to establish collection in store. On the other hand, limitation would be the obligation of consumers to buy new EEE when they bring WEEE. Furthermore, optional character of the provision that producers can establish their own collection and obligation to consult with municipalities further decreased the relevance of the discussed provision. During transposition of the WEEE Directive responsibility based on 1:1 rule was abandoned while distributor responsibility was opted out as well.

After the agreement with the producers, municipalities were left with the task of establishing collection system from households to ÅVCs. Establishing household collection implied additional costs for the residents through municipal charges. Therefore, the residents were left with a choice. They would either have to invest time, effort and money to access ÅVC in order to dispose GDL waste or participate in the municipal household collection (curbsides, store collection etc.) which included municipal charges. It should be noted that here it is not only the problem that residents have to pay. It is the fact that this kind of payment is in a form of municipal charge, which is a specific cost that depends upon resident's decision to accept the collection service. Furthermore, both personal investments in disposal and municipal charge are occurring in the context where producer should be legally responsible, however, instead, due to "El Retur" cooperation, the costs are allocated to residents. Therefore, the context and the feature of the payment further decreases the capacity and the motivation factor as was previously suggested.

Although it is preferred that producers are responsible for waste of the product they manufactured, the problem in this case is that responsibility for household collection was not clearly defined. Theoretically, municipalities could be made responsible and general obligatory taxes introduced which could lead to effective household collection. Of course, in this case public opposition might increase due to newly established financial burden. The main point is that the exact specification of physical and financial responsibility for household collection is lacking whether it producer or municipality's responsibility. The way the legal principles were applied in Ordinance 2005:209 as well as the logical arguments associated with the EPR and polluter pays principle suggest that producer responsibility for household waste collection should be more specified.

Waste Ordinance SFS 2011:927 and previously Waste Ordinance SFS 2001:1063 established the rule that holders of WEEE (implying residents) had to sort WEEE. The author argues that this provision decreased motivation of both municipalities and producers to establish household collection. The reason is that residents are legally responsible for sorting WEEE, Producers and due to “El Retur” cooperation municipalities’ responsibility is concerning responsibility to accept the WEEE from residents without taking any penalties in case the resident discards the waste improperly.

Finally, based on data and interpretation presented, it could be said that the key Swedish policy elements responsible for ineffective GDL waste collection are:

- Collection targets based on weight of total WEEE collected per year;
- Lack of exact specification of physical responsibility for household collection;
- Lack of exact specification of financial responsibility for household collection;
- Exclusion of distributor responsibility; and
- Responsibility to sort waste was assigned to residents while producers and municipalities are not liable for unsorted waste.

Similar for Swedish policy key EU policy elements manifested in the WEEE Directive regarding ineffective waste collection that reflected on Swedish case are:

- Collection targets based on weight of total WEEE collected per year;
- Lack of specification of household physical responsibility;
- Lack of specification of household financial responsibility;
- Optional character of the distributor responsibility; and
- Absence of state/municipal/producer liability for unsorted waste.

It should be noted however, that the new WEEE Directive is currently being developed through cooperation between the European Commission and the EU Parliament. A compromise text was adopted on January 19 2012. It contains certain provisions that might give incentives for the improvement of the household GDL waste collection.

First, a compromise text contains a provision that the common methodology for estimating collection rate should be developed. Collection targets should be expressed as collection rate starting from 45% as a requirement after the adoption of the new WEEE Directive and gradually increasing the collection target to be 65% of the collected WEEE.

Second, governments may if appropriate, encourage producers to finance the costs of collecting WEEE from private households to collection facilities.

Third, the compromise text contains the provision that the Member States shall achieve high level of separate collection of WEEE from certain types of WEEE which includes GDLs.

Fourth, Article (2) states the following:

Member States shall ensure that distributors provide for the collection, at retail shops with sales areas relating to EEE of minimum 400 m², or in their immediate proximity, of very small WEEE free of charge to end-users and with no obligation to buy and EEE of equivalent type, unless an assessment shows that alternative existing collection schemes are likely to be at least as effective.

It is encouraging that during the process of new WEEE Directive development the issue of GDL waste collection was seriously taken into account. Some of the provisions will offer optional rather than obligatory rules for the Member States. Nevertheless, it is important that different possibilities were mentioned and discussed about. Final outcome is still uncertain, however, it is probable that the final version of the new WEEE Directive will include specific rules regarding GDL household waste collection. Such outcome will consequently be reflected in the Swedish legislation during transposition of the new WEEE Directive.

5.2 Policy Scenarios

Following the defined methodology, sub-solutions will be defined for four sub-functions (enhance opportunity, capacity, motivation, established routines). Plenty of sub-solutions could theoretically be listed in order to serve four sub-functions. However, in this paper information derived from waste collection and policy review will be derived in order to come up with most practical and possible sub-solutions.

Collection in store, Curbside collection and mobile vehicle with fixed positions could be perceived as sub-solutions that could enhance opportunity and capacity. That is because the residents do not need to travel long, have a car, invest money, time or effort to access these collection points. Collection in store would also enhance established routines especially in the case of grocery stores since residents already visit grocery stores regularly to buy certain articles or to dispose packaging waste.

Refund for returned package could be perceived as a sub-solution to enhance motivation since the residents would have a financial incentive and reward for returning the GDL waste. It can be assumed and policy review supports this assumption, that, refund from in stores would present the most practical application. Due to proximity and established routines, consumers often visit store and leave waste while getting refund in return. Furthermore, distributors would also be compensated for waste disposal service, instead of just having responsibility associated with extra costs. The example of deposit-refund could be found in Austria from 1992 until 2005 when the system was dissolved (Ecologic, 2005). The obligatory deposit per lamp was EUR 0.70 per lamps, including VAT (Lampenverordnung, 1992). Unfortunately, no further information could be obtained during this research.

Producer financial responsibility for household collection could be perceived as a sub-solution to enhance capacity and motivation. Residents would not have to bear the additional municipal costs of collection system through charges. They will be more motivated to participate in collection instead of preferring to avoid costs through storage or inappropriate disposal. This kind of sub-solution could reflect in different kinds of collection forms depending on practicalities. The assumption would again be that a deposit-refund system presents a logical option. On the other hand, the issue of producer physical responsibility from the residents' perspective is not of much relevance because for the residence the important issue is the existence of close access to collection points at least free of charge. However, establishing physical responsibility might assure producer's control regarding proper usage of their funding.

Another issue that might stimulate producers to establish collection that increase convenience is the shift of sorting responsibility from residents to producers. In this case producers would have to pay a fee for unsorted GDL waste found in other waste. Depending how these fees are set producers might be more in favor for deposit-refund system. The option of refund would increase the probability of proper sorting and decrease the probability of paying fee resulting from improper disposal by residents.

Finally establishing separate waste collection targets for GDLs based on percentage could be perceived as a sub-solution that would increase the possibility for establishing convenient household waste collection. Different sets of more concrete above mentioned sub-solutions might occur in order to meet the required waste collection targets.

Different sets of sub-solutions could finally be integrated into policy scenarios with a more encompassing long-term perspective.

These scenarios are:

1. **Business as usual.** There will be no active changes of already established policies. Established cooperation between municipalities and El-Kretsen would continue its operation. Certain changes might be adopted as a response to the new WEEE Directive that is under preparation. The change inside Sweden will mainly depend on negotiation between municipalities and El-Kretsen. As it was presented during policy review, current Government is closer to meet municipalities demand for increase of financial share from producers. However, further share of responsibilities will also differ from dynamics in political sphere;
2. **Limited policy change.** Certain changes might occur that may range from introducing distributor responsibility and more convenient curbside collection to establishing a deposit-refund system for waste GDLs probably covered by producers; and
3. **Drastic Change.** This scenario implies establishment of producer responsibility in reality and more specific provisions in the legal sphere. Producers would have to cover the financial costs of household collection. This might include establishment of physical responsibility possibly through producers' initiative. The fullest extent of this scenario would include EPR combined with specific obligation to establish deposit-refund system and liability for unsorted waste GDLs including introduction of fee.

6 Conclusions

6.1 Summary of the Presented Research

In this paper a research was conducted regarding status and trends for development of an effective glass-discharge lamp (GDL) household waste collection in Sweden in the context of incandescent light bulb phase-out. Collected data included a literature review acquired through online search and interviews of the relevant stakeholders. The study included establishment of the analytical framework consisting of waste collection review, waste collection evaluation, policy review and policy analysis.

The analytical framework applied the elements of previous research conducted by Lindhqvist (2000), Melissen (2006) and Wagner (2011). Waste collection review included presentation of data collected. Waste evaluation included application of Triad model previously applied by Melissen combined with Wagner's findings regarding importance of the convenience factor for residents' disposal behavior concerning waste GDL. The evaluation finally consisted of comparing discovered waste collection forms with four factors relevant for residents' waste GDL disposal behavior: opportunity, capacity, motivation and established routines. Policy review included review of current status and historical policy development. The review was consisted of collected data on relevant legislation and statements from the key stakeholders. Policy analysis applied Melissen's morphological chart in order to develop sub-solutions, policy scenarios and finally an answer the research question.

The results of the waste review showed that current collection rate estimations offer no certain information regarding GDL collection. This is especially the case regarding collection rates of the household GDLs, namely, compact fluorescent lamps (CFLs). Limitations are associated with difficulty to determine a level of consumption of GDLs and waste electrical and electronic equipment (WEEE) in general, lack of common methodology to conduct measurement and randomness of the pick analysis. Existing waste collection includes municipal recycling centers, rural collection points, curbside collection, collection with vehicles with fixed position and collection in store. The last form of collection is regarded still to be experimental, although the usage of Collectors in store is increasing.

The evaluation showed that GDL household waste collection can be regarded as inconvenient and waste policies as ineffective. Municipal recycling centers – återvinningscentraler (ÅVCs) have low proximity to households, require residents to have access to car and additional residents' effort, time and further financial investments. Curbside collection includes safety risks and municipal waste charges. It is expected that residents would hesitate to conform with such system features. Vehicle with the fixed collection points offers more potential. However, it may also be inadequate because it demands residents' to adjust their routines to the vehicles time schedule of movement. Collection in store potentially offers the most benefits for residents to dispose their GDL waste.

Policy review showed that current Swedish policy includes producer responsibility for GDL waste collection which is practically shared with municipalities. Furthermore, collection targets are based on weight for the total amount of WEEE of which GDL is constitutes only one small element. The way collection targets were formulated might explain the difficulties associated with the current GDL collection rate estimations. Current Swedish policy is a transposition of European Union (EU) rules for GDL waste collection contained in the WEEE Directive. Main stakeholder criticisms revolved around defined targets, responsibility for waste collection and in case of producers complaints about the high costs of GDL waste recycling. Development of current household GDL waste collection policies featured

Ordinance SFS 2000:208 on producer responsibility for WEEE as well as suggestions from the political and academic circles for establishment of a deposit-refund system for GDLs.

Results from policy analysis showed that potential policy scenarios might include: existing case based on producer and municipal negotiations over the waste collection responsibility with sporadic governmental intervention; introduction of small scale changes such as deposit-refund system, distributor responsibility or more convenient curbside collection; and drastic changes featuring extension of producer responsibility for GDL household waste collection with possible inclusion of additional specific policies.

6.2 Answers to the Stated Research Question

The research question was stated as follows:

How can Swedish policy makers achieve effective household waste collection of mercury-containing lamps while maintaining the phase-out policy for incandescent light bulbs?

From the former analysis, it can be concluded that the stated research question can involve multiple set of policies, mainly associated with second and third policy scenario. These policies for effective household GDL waste collection could be listed as follows:

- Formulation of specific waste collection targets for GDLs expressed in collection rate;
- Deposit-refund system;
- Specification of physical producer responsibility for GDL waste household collection;
- Specification of financial producer responsibility for GDL waste household collection;
- Introduction of distributor responsibility; and
- Combinations of the former answers.

6.3 Final Remarks

A final reflection regarding the conducted study is the following. First, the use of morphological chart should be improved. The way it was used in this study involves subjective elements which open space for arbitrary assessments. A more quantitative approach should be applied to evaluate waste collection. Geo-information systems (GIS) should be applied to measure proximity of collection point to household. Accounting and quantitative data processing should be implemented in order to measure costs associated with different collection schemes. Time and resource constraints prevented such research from being conducted. Second, it is important to conduct more interviews in order to understand the full complexity of policy and the stakeholder dynamics. Third, it is important to analyze experience of other countries in the EU and on the global level in order to make comparisons and gain additional insights. Fourth, more quantitative data is generally required regarding, collection estimations, charges and waste collection costs. Nevertheless, even with the before mentioned limitations, analysis of the Swedish experience regarding waste collection policies might offer useful information to policy makers, academia and other relevant stakeholders regarding GDL household waste collection in Sweden and for other countries at the EU and global level.

Bibliography

Avfall Sverige. (2009). *Fastighetsnära insamling av farligt avfall från hushåll* [Building-based household collection of hazardous waste]. Rapport U2009:20.

Avfall Sverige. (2010). *Insamling av elavfall i butik försök med insamling av elavfall i Samlaren under ett år* [Collection of waste electrical and electronic equipment in store with one-year trial of waste electrical and electronic equipment with collector]. Rapport U2010:08.

Avfall Sverige. (2011). *Vart tar smått el-avfall från hushåll vägn?* [Where does small waste electrical and electronic equipment go?]. Rapport 2008:03.

Åhnberg A., Jennehag J., Hurtig B., Claesson V., Chrisopoulos A., Strömdahl J., Ragnarsson J. (1991). *En god livsmiljö* [for good environment]. Motion 1990/91:Jo107. Stockholm: Riksdagen.

Begley K., Linderson T. (1991). *Management of Mercury in lighting Products*, Proceedings of the 1st European conference on energy-efficient lighting. 1991. E. Mills (ed) Swedish National Board for Industrial and Technical Development, Department of energy efficiency, Stockholm.

Council of European Municipalities and Regions. (2006). *Review of Directive 2002/96/EC on Waste electrical and electronic equipment (WEEE) comments from CMER*.

Darby L., Obara L. (2005). Household Recycling Behaviour and Attitudes towards the Disposal of Small Electrical and Electronic Equipment, *Resource, Conservation and Recycling* 44 17 – 35.

Ecologic gGmbH. (2005). *Abfallvermeidung und Verwertung durch das Prinzip der Produzentenverantwortung* [Waste prevention and recycling through the principle of producer responsibility]. Berlin: Institut für Internationale und Europäische Umweltpolitik.

ECOS, EEB, ZMWG, CAN-Europe, INFORSE-Europe, Greenpeace and WWF. (2008). *Position from ECOS, EEB, ZMWG, CAN-Europe, INFORSE-Europe, Greenpeace and WWF on the EC Working Document on possible ecodesign requirements for general lighting equipment*.

El-Kretsen. (n.d.). *Insamlingsresultat 2008 & 2009* [collection results 2008&2009].

El-Kretsen. (2009). *16,4 miljoner lågenergilampor och lysrör återvanns 2008* [16.4 million compact fluorescent lamps and fluorescent tubes collected in 2008]. Pressinformation.

El-Kretsen i samarbete med Sörab. (2011). *Framtidens insamlingsystem för smått el-avfall* [Future collection of small waste electrical and electronic equipment].

El – Kretsen. (2012). *Statistic 2010 & 2011*, Pressinformation.

European Commission. (2008). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – 20 20 by 2020 – Europe's climate change opportunity*.

European Commission. (2011). *Frequently Asked Questions about the regulation on Ecodesign*.

European Commission. (2009). *Commission Regulation (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with to ecodesign requirements for non – directional household lamps*.

European Commission. (2006). *Directive 2006/66/EC of the European Parliament and the Council of 6 September 2006 on batteries and waste accumulators and waste batteries and accumulators and repealing Directive 91/57/EEC*.

- European Commission. (2005). *Directive 2005/32/EC establishing a framework for the setting of ecodesign requirements for energy using products*.
- European Commission. (2002). *Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE)*.
- European Committee of Domestic Equipment Manufacturers. (2004). *Raising a red flag over the flawed WEEE Directive: Q&A on why CECEDE is raising a red flag over how the WEEE Directives' producer responsibility principle is supposed to be put in practice*.
- European Environmental Bureau. (2005). *"Zero Mercury, Key issues and policy recommendations for the EU Strategy on Mercury"*.
- European Environmental Bureau & Zero Mercury Working Group. (2008). *"Mercury Containing Lamps under the Spotlight"*. Brussels: conference report.
- European Environmental Bureau. (2009). *"EEB Position Paper on the proposal for the revision of the directive on waste electrical and electronic equipment"*.
- European Light Companies Federation. (2006). *Let there be Light, Fiat Lux*.
- European Light Companies Federation. (2009). *Questions and answers on the EU decision to phase out incandescent and less energy efficient lamps*.
- European Parliament. (2012). *European Parliament legislative resolution of 19 January 2012 on the Council position at first reading with a view to the adoption of a directive of the European Parliament and the Council on waste electrical and electronic equipment (WEEE) (recast)*.
- Frebran R. (1993). *Anfallsbhantering av lysrör* [Disposal of fluorescent lamps]. Motion 1992/93:Jo652. Stockholm: Riksdagen.
- Hagberg C. (2007). *Uttjänta lampor* [Discarded lamps]. Motion 2007/08:MJ287. Stockholm: Riksdagen.
- Hägg C. (1998). *Återvinning av lampor* [Recycling of lamps]. Motion 1998/99:MJ741. Stockholm: Riksdagen.
- International Institute for Industrial Environmental Economics, Okopol, RPA. (2007). *The producer responsibility principle of the WEEE Directive*.
- Lindhqvist, Thomas. (2000). *Extended Producer Responsibility, Policy Principle to Promote Environmental Improvements in Product Systems*, Doctoral Dissertation, Lund University.
- Melissen F. W. (2006). Redesigning the Collection System "Small" Consumer Electronics, *Waste Management* 26 1212-1221.
- Mills E. (1991). Evaluation of European Lighting Programs, Utilities Finance Energy Efficiency, *Energy Policy*, Volume 13, Issue 3, Pages 266-278.
- Ministry of Environment (Sweden). (1998). *The Environmental Code*.
- Naturvårdsverket. (2003). *Samla in, återvinn!: Uppföljning av producentansvaret för 2003* [Collect, recycle!: Monitoring of producer responsibility for 2003].
- Naturskyddsföreningen. (2011). *Inför pant på lågenergilampor* [prior to deposit of compact fluorescent lamps].

Naturvårdsverket. (2009). *WEEE Directive in Sweden – Evaluation with future study*.

Naturvårdsverket. (2012). *Samla, in Återvinn!* [Collect, recycle!]. Rapport 6482.

Naturvårdsverket. (2010). *Samla in, återvinn!* [Collect, recycle!], Rapport 6328.

Naturvårdsverket. (2011). *Sammanställning av rapporteringen av elektriska och elektroniska produkter till Naturvårdsverket åren 2008 & 2009* [Compilation of reports of waste electrical and electronic equipment for Environmental protection agency in 2008&2009].

Petersson O. (1993). *Pant på kvicksilverlysror* [Deposit for mercury-containing lamps]. Motion 1992/93:Jo693. Stockholm: Riksdagen.

Petersson O. (1994). *Bättre kontroll över miljöfarligt avfall* [Better control of hazardous waste]. Motion 1993/94:Jo18. Stockholm: Riksdagen.

Petersson S. (1991). *Pant på kvicksilverlysror* [Deposit for mercury-containing lamps]. Motion 1990/91:Jo719. Stockholm: Riksdagen.

Petersson S. (1992). *Pant på kvicksilverlysror* [Deposit for mercury-containing lamps]. Motion 1991/92:Jo602. Stockholm: Riksdagen..

Poiesz, T.B.C. (1999). *Gedragmanagement: Waarom mensen zich (niet) gedragen* [Behavior(al) Management: Why people (don't) behave]. Inmerc bv, Wormer: the Netherlands.

Renova. (2011). *Samlaren för farligt avfall* [The collection of hazardous waste].

Strahl J., Ryden E. (1995). *Extended producer responsibility in the lighting sector*, 3rd European conference on energy-efficient lighting.

Swedish Government. (2005). *Ordinance on Producer Responsibility on Electrical and Electronic Products*.

Svensk författningssamling 2000:208 [Swedish Code of statutes]. (2000). *Förordning om producentansvar för elektriska och elektroniska produkter* [Ordinance on producer responsibility for waste electrical and electronic equipment].

Swedish Code of Statutes 2005:209. (2005). *Ordinance on producer responsibility for electrical and electronic products*.

Svenska Dagbladet Nyheter. (2011). *Kvicksilvret I lampor går rätt ut naturen* [Mercury from lamps is going straight into nature].

Svensk författningssamling 2011:927 [Swedish Code of statutes]. (2011). *Anfallsförordning* [Waste ordinance].

Svenska Dagbladet Nyheter. (2012). *Branschen lovar att samla in tio miljoner lampor* [The industry promises to collect 2 million lamps].

United nations University. (2008). *2008 Review of the Directive 2002/96 on Waste Electrical and Electronic equipment (WEEE)*: Bonn.

Verordnung über die Rücknahme, Pfandhebung und Umweltgerechte Behandlung von bestimmten Lampen (Lampenvorordnung) [Ordinance of the withdrawal, deposit collection and treatment of certain energy-efficient lamps (lamp Ordinance)]. BGBl. Nr. 144/1992.

Wagner T. P. (2011). Compact Fluorescent Lamps and the impact of Convenience and Knowledge on Household Recycling rate, *Waste Management* 31 1300-1306.

Appendix

Interviewed stakeholders and questions used for conducting interviews.

Stakeholders interviewed:

1. Avfall Sverige
2. Lighting industry (Belysningbranschen)
3. Hässleholm municipality

Thematic units and questions:

Collection rates

1. Does (stakeholder) have specific estimations of its own regarding collection of gas discharge lamps (GDL)?
2. What is your opinion regarding EPA's and El-Kretsen's collection estimations?

Historical Development of Policy Debate

1. What were the main positions of (stakeholder) and other stakeholders regarding GDL collection?
2. What were the specific positions of (stakeholder) regarding GDL collection in the context of phasing out of incandescent bulbs?
3. What were the positions of (stakeholder) regarding potential expansion of producers responsibility to source collection?
4. What were the positions of other relevant stakeholders?
5. What were the positions of (stakeholder) regarding distributors responsibility?
6. What were the positions of (stakeholder) regarding introduction of the deposit-refund system?

Future Development

1. What would be the possible outcomes at the policy level regarding improvement of the GDL waste collection in the context of the recent agreement between the Ministry and the waste management sector?
2. What are the drivers & barriers regarding introduction of the distributor responsibility?
3. What are the drivers & barriers regarding potential extension of the producer responsibility to source collection?
4. What are the drivers & barriers regarding introduction of the deposit-refund system for GDL collection?