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Chapter 13

How to Get Stuff Back?

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In order to recycle or re-use products that contain Critical Raw Materials (CRMs), these products have to be collected from consumers and professional organizations (e.g. businesses) first. Waste Electrical and Electronic Equipment (WEEE) is collected for economical, environmental, and public health and safety reasons. Lessons can be learned from the collection of WEEE, such as how to influence and stimulate consumers to collect WEEE separate from other waste, and how to stimulate and train companies in separating waste.

13.1 Introduction

Critical Raw Materials (CRMs) are to be found in all kinds of products; e.g. Electrical and Electronic Equipment (EEE) and alloys. Retrieving the CRMs from disposed or End-of-Life (EoL) products starts with collecting these products in such a manner that separation techniques in combination with hydro- and pyro-metallurgy are able to operate with the highest possible yield. Products are also retrieved for partial or complete re-use of the product, such as remanufacturing activities. To comply to legislation the collection of products is organized by governments or producers. The effectiveness of the collection of disposed products depends on the behavior of consumers and professional organizations.

13.2 Organizing the Return of Disposed Products

Waste Electrical and Electronic Equipment (WEEE) has been collected for recycling purposes throughout the world. The drivers for governments, NGOs and companies to collect WEEE are[23]:

- Economical. In the case that the value of the metals is higher than the cost of retrieval: e.g. collection and recycling costs.
- Environmental. By recycling and (partial) re-use WEEE will not be landfilled or incinerated, preventing leaching of harmful substances to the environment. Recycling will reduce the global demand for metal production, reducing greenhouse gases and harmful substances formed by mining and processing ore. Recycling also saves energy in comparison to the processing of ore to retrieve virgin metals.
- Public health and safety reasons. Recovery of metals in the informal sector, as well as landfilling or incineration with poor or no environmental standards can create harmful substances of such a level that public health and safety are compromised.

Current practices worldwide of returning WEEE are[23]:

- Official take-back systems, via municipalities, retailers or commercial pick-up services.
- Disposal with mixed residual waste to landfills and incineration. If the metals of WEEE are not separated before or after (from the bottom-ash) incineration or landfilling, toxic leachate from landfills or incinerators ash or harmful air emissions from incinerators will compromise the environment and public health.
- Collection outside the official take-back systems. WEEE is collected by individual waste dealers or companies for metal and/or recycling or export. In many cases this export is not legal.
- Informal collection and recycling in developing countries, usually by self-employed people. If the collected WEEE does not have any value, it is landfilled or incinerated causing damage to the environment and public health.

In order to organize the return of WEEE, different countries have adopted legislation. The European Union adopted the WEEE directive (2002/96/EC) focused at collection targets. With the Home Appliance Recycling Law (HARL) and Small Appliance Recycling Law, Japan wants to increase the recycling rate. Australia aims to improve this with the

National Waste Policy and the National Television and Computer Recycling Scheme. India has "Guidelines for environmentally sound management of e-waste" focused on the collection and recycling of e-waste. Indonesia and the Philippines are working on e-waste legislation.[47] China started extended producer responsibility practice for WEEE recycling in 2011.[23]

The aim of the WEEE directive (2002/96/EC) of the EU is "encouraging the design and production of electrical and electronic equipment which takes into full account and facilitates their repair, possible upgrading, reuse, disassembly, and recycling". For this "each producer should be responsible for financing the management of the waste from his own products". The financial and physical responsibility of the stakeholders varies per EU country for:[36]

- Producers: the set-up of own collection points or for provision of collection containers, and the funding of collection systems, sorting, trans-shipment, treatment, and bulk transport.
- Local authorities: the obligation to WEEE take-back or to own WEEE management by direct trading.
- Retailers: the obligation to WEEE take-back.
- Recyclers: the optional direct trading of WEEE and the obligation to downstream reporting of WEEE streams.
- Coordinating body/clearing house: the registering of WEEE put on market, managing take-back of WEEE on request and joint communication on WEEE collection.

In China, the formal and in most cases state-controlled recycling of WEEE is financed via a product tax for five types of appliances: TV-sets, air conditioning, washing machines, refrigerators, and computers. The recyclers have to collect WEEE through their own collection schemes or via traders. Municipalities and retailers do not have a role in WEEE collection. The WEEE management is the responsibility of six governmental agencies. The structure of these agencies with interdependent, aligned, and sometimes overlapping responsibilities makes effective and efficient WEEE management more difficult.[36]

13.3 Stimulating Consumers

The effectiveness of collection systems of WEEE and other EoL-products that contain CRMs depends on the motivation of consumers to separate these EoL-products from the residual waste. The motivation of consumers

can be explained by psychological models. These models can explain the behavior and encourage consumers to engage in waste separation. Based on the behavior of consumers, the effectiveness of collection systems and communication about waste separation can be enhanced.

13.3.1 *Psychological models*

Regularly used psychological models to explain the waste separation behavior of consumers are:

- TPB: Theory of Planned Behaviour[4,43,44]
- IMB: Information-Motivation-Behaviour Skills model[38]
- CADM: multilevel Comprehensive Action Determination Model[22]

The TPB is based on the hypothesis that the behavior of an individual follows directly from the intention of an individual. The intention of an individual is influenced directly by three factors:

- Attitude towards the behavior: the individual's evaluation (favorable or unfavorable) of performing the behavior. Example: An individual can be involved in social and societal responsible actions and therefore waste separation is important for that individual.
- Subjective norm: the individual's perception of social pressure to perform or not to perform the behavior. Example: A student stops waste separating in a student house (dorm) because fellow students have a negative attitude towards waste separation.
- Perception of control: perception of the individual's own ability to carry out the behavior. Example: An individual wants to separate waste but thinks that the recycling bins are too far away or are difficult to find.

In the model it is assumed that personality, past experiences and demographic characteristics also affect the individual's behavior, and indirectly affect the above three factors of the model, and are therefore included in the model.

CADM (multilevel Comprehensive Action Determination Model) is based on the TPB model. The model assumes that behavior in waste separation is determined by:[38]

- The intentions of an individual
- Conditions given by the circumstances of an individual
- Habits of an individual. These are influenced by the perception of control (TPB model) and the intentions of the individual, because habits develop over time.

The CADM model studies actual existing barriers and facilities that influence behavior (in this case waste separation) and the link to the subjective barriers and facilities (experienced by the individual).

The IMB-model (Information-Motivation-Behavioral skills model) assumes a connection between the three factors:[22]

- Information: Information known by an individual related to engaging in waste separation behavior. Examples are the knowledge of the locations of waste bins for waste separation, or the knowledge on how and what to bring to these bins.
- Motivation. The motivation of an individual is determined by his/her own perception of the behavior, and the need for the behavior to conform to a social norm.
- Skills: The simple skills of an individual to separate waste for recycling and to offer recyclable waste at regular collection days.

The IMB model implies that information and motivation for waste separation defines the specific skills to separate waste. The skills determine the behavior of waste separation.

13.3.2 *Influencing and stimulating behavior*

The recycling behavior of consumers can be influenced positively (encouraging) or negatively. This section discusses the behavior of consumers, the general primary consumer attitudes on waste separation, promotion opportunities (pay-per-bin, education, and regulation), and finally, the influence of external circumstances on the consumer.

13.3.2.1 *Waste separation behavior of consumers*

Seacat and Northrup[38] researched the waste separation behavior of consumers with the IMB model and concluded that more waste separation occurs when there is more information available about waste separation and when people become more motivated. These aspects determine the waste separation abilities (skills) of consumers. The researchers emphasize that collection systems are used more if these systems are simple to use according to consumers. The convenience of separate waste collection systems is an important condition for waste separation.

The TPB model is based on the assumption that the behavior of a consumer depends on the attitude towards that behavior, subjective norms (social pressure) and the perception of control (perception of the possibility and difficulty of waste separation). Tonglet *et al.*[44] conclude that

the knowledge and opportunity for waste separation are important factors to encourage waste separation, but consumers should not be deterred by the problems that physical waste separation may entail, such as lack of convenience, place for bins at home, and available time. Besides this, experience with waste separation in the past and its importance for society are also important factors. Another study[25] confirmed this. This study looked at the effect of the perception of distance to facilities for waste separation and the actual distance. A significant relationship was found between the perception of the distance to waste separation facilities and waste separation behavior, rather than between the actual distance and waste separation behavior. The perception of that distance had an even larger influence on waste separation than the intention to separate waste.

The CADM-model assumes that waste separation behavior, as in the TPB-model, also depends on the intentions of an individual, the conditions created by the circumstances of an individual and the habits of a individual. The conclusions of the study of Klöckner and Oppedal[22] are in line with the two studies described above; waste separation behavior is determined by the intentions and habits of an individual and by the conditions created by that individual's circumstances. On the individual's personal level, waste separation behavior is determined by the intention to separate waste and by the waste separation habits the individual has developed, but external circumstances in the waste separation system play an important role. A study of waste separation practices shows that people who have the intention to separate waste also have the perception that the collection system makes waste separation easy.

The above mentioned psychological studies are in line with the conclusions of econometric and statistical research conducted in Sweden.[5,17] These Swedish studies show that if the infrastructure of collection systems is considered as marginally helpful by consumers, waste separation then depends on strong personal, moral and social norms. The publicity required to maintain these strong norms amongst the public becomes less important when consumers perceive the waste collection systems as more convenient. This is confirmed by a study on oral communication.[6] In this study it appears that oral communication by door-to-door visits on the separate collection of food waste has little impact on the separate collection behavior. Access to collection systems, however, has a major impact. Research on the separate collection of WEEE[37] suggests that internal factors such as social pressure and attitude are the most important variables to explain the intention of

households to collect WEEE. The second most important variable is the convenience of separate waste collection. A study showed that if separate waste collection systems are considered to be sufficiently convenient and available, more waste is separated in mass (kilograms) and types of recyclable material.[12] This is also shown in a study on separate waste collection behavior in schools.[33]

Case: CFLs

A case study on recycling Compact Fluorescent Lights (CFL)[45] shows that availability and convenience of separate waste collection systems are important factors. This study was conducted in the state of Maine in the United States. In 2009, 520 people were questioned on the separate collection of discarded CFLs. That few CFLs were collected appeared to be the result of:

- Insufficient knowledge about recycling CFLs
- The lack of convenience of collection systems

The researchers recommended waste collectors to make the collection of CFLs more convenient and to make any access to information to consumers on the collection of CFLs more simple.

13.3.2.2 *General attitudes of consumers*

In the previous section researchers concluded that separate waste collection depends on the attitude of consumers and the waste collection systems. This section describes three cases about consumer attitudes, the personal and social circumstances that determines if a consumer will separately collect waste.

Case: Batteries

In a case study on the collection of batteries in Switzerland,[18] 1,000 consumers were surveyed by mail. This study shows that the factors that positively influence waste separation behavior are:

- Knowledge about recycling batteries
- "Organizing" battery collection at home
- Disagreeing with reasons why not to separately collect batteries

The attitude of the respondents towards an ecologically better waste collection (better for the environment) and confidence in the authorities who collect waste, did not seem to be reasons to collect batteries separately.

Case: WEEE collection in Cardif

In a study on the collection of WEEE at waste collection sites in the Cardiff area (United Kingdom) nearly 5,000 people were asked to complete a survey.[11] The survey showed that households who already collect other types of materials separately (e.g. paper, glass, cans and plastic) were also more likely to collect WEEE. Many respondents who collected separated waste indicated that they would visit other waste collection sites as well, if they could bring their separated WEEE. The researchers also noted that through separated waste collection consumers became more aware about this topic and asked for more opportunities for separate waste collection of other types of waste materials. The households did not want to have more information about the importance of separated waste collection, but wanted information on how to collect waste materials and EoL-products separately.

Case: Organic waste

In Wyre (UK), a survey was conducted with more than 2,500 completed surveys on collection of green waste. The response rate was 50%. The study[46] on these surveys showed that respondents aged 25 to 44 years were the least likely to separately collect organic waste, possibly due to a lack of time. The survey also showed that the public desired more information and services to facilitate the collection of waste separated by type.

13.3.2.3 *Financial incentives*

In Minnesota (USA), researchers[41] analyzed data from the collection of recyclable waste on the effect of differentiated rates (pay-per-bag) for separated waste collection, on informing the public, and on waste collection systems. The researchers concluded that differentiated rates for waste disposal significantly increase the amount of separately collected recyclable materials.

In a survey among residents of the London borough, Havering, respondents seemed to have a lower response to financial incentives than to improving the plan on separate waste collection itself, in particular the waste collection infrastructure and support.[40] The financial incentives that could possibly have an impact were, according to those surveyed:

- rewards over penalties; and,
- financial rewards at the community level (e.g. for improvements in the neighborhood) or as tax refunds or reduction in the municipal taxes, rather than individual rewards.

In 2005 and 2006, in Portsmouth (United Kingdom) providing financial incentives were compared to informing people at the door ("doorstepping") on separated waste collection, and with a feedback card in the mail-box when the separated waste collection was done incorrectly, or not at all.[42] The feedback card was encouraging and had an informative tone. The "doorstepping" was regarded as successful, but only relatively few households were reached. The feedback card was very effective and relatively cost-effective. The financial incentives consisted of rewards for households if more recyclable materials were collected separately. The study did not show that financial incentives were effective as a method to encourage recycling. Only 13% of respondents mentioned that financial incentives were the main reason to collect and separate recyclable waste.

13.3.2.4 *Effect of housing type*

Researchers studied the impact of the housing type on separate waste collection in the London borough of Havering.[39] The researchers counted the number of households that collected separated recyclable waste, and compared that to the number of households in a street. The numbers showed that streets with detached houses have more households that collect separated waste than streets with terraced houses or flats. The researchers believe that separated waste collection will be improved at terraced houses and flats when social interactions are improved. In improving these social interactions, street architecture can have an influence.

13.3.2.5 *Effect of income on separate waste collection*

The effect of income of households on separate waste collection has been researched in several studies. However, these studies do not give a definitive conclusion. A study conducted in the state of Minnesota in the United States,[41] shows a marginal decrease in income at the increase in the volume of separately collected materials: 0.2 percentage points per US $1,000 increase in income. A study conducted in Belgium[14] with data from 2003 is in line with the study of Sidique *et al.*[41]: in households with a higher income per capita less recyclable waste is collected separately.

A study conducted in Cardiff (United Kingdom) showed that households with an income of less than £10,000 collected less WEEE for recycling than households with higher incomes.[11] The researchers do note that less WEEE was found in the residual waste from households with

low incomes. The researchers explain this effect at households with low incomes on:

- Less availability of suitable transport (often a car) to bring the WEEE to a recycling center, which in many cases was three to four kilometers away.
- Keeping electrical and electronic products longer and giving them away to others rather than disposing of them as waste.

13.3.2.6 *Social groups: students and British-Asians*

Researchers[33] have studied the attitude on separate waste collection of students at a high school in California in the United States. It was found that more recyclable waste was collected after it was explained which materials were to be collected and how they were to be collected. The collection systems had to be accessible and consistently at the same location. The usefulness of separated waste collection was already known to the students; among students this was already the norm. The researchers recommend that communication to students about separated waste collection should not focus on the importance of recycling. The advice was to make students ambassadors in separated waste collection campaigns toward adults (teachers, parents). The researchers noted that students have a broader perspective on the world and are more future-oriented than adults often assume.

A British study showed that the recycling behavior of the British Asian community in Burnley was no different from the other inhabitants of Burnley.[26]

13.3.3 *Effectiveness of collection and delivery systems*

The effectiveness of collection systems for recyclable waste depends on different variables. These variables are the frequency of pick-ups, the size of containers for recyclable and residual waste, and the set-up of collection points where consumers could bring their recyclable discarded products. This section describes these variables.

13.3.3.1 *Frequency of pick-ups and the size of containers*

In the UK, an econometric study was carried out on the collection or "pick up frequency of "dry recyclebles" (e.g. waste paper, cans, plastics), "compostables" (organic waste), and residual waste.[1] In the UK recyclables such

as waste paper, cans, and plastic bottles are collected in one container or one plastic bag. This collected "dry recycleble" material is mechanically separated. The researchers studied data from different regions in the UK on the collection rate of the three above-mentioned types of discarded materials. A relationship was found between the frequency of the pick-up of the residual waste and the percentage of waste that has been recycled. It appeared that the less often residual waste was collected, the more "dry recyclables" and organic waste was collected. The researchers recommended against the plans of local authorities to collect more garbage. The researchers found that the type of bin for "dry recyclables" determines the amount of "dry recyclables" collected. Collection with the wheelie bin with a maximum of 120 liters gave the most "dry recyclables". A plastic bag, a wheelie bin of 180 to 240 liters and more than 240 liters also provide more collection. The researchers found an increase in collected organic waste when this material was collected only once a week. However, this was not the case for all seasons.

A study carried out in Belgium with data from 2003[14] showed that the collection of recyclable materials increased when

- residual waste was collected once every two weeks instead of once a week
- there is an extra collection system for organic waste; for example an additional "green bin".

In addition to the influence of pay-per-bag, which caused an increase of separated waste collection, a collection system for organic waste had the largest positive influence on more separated waste collection.

13.3.3.2 *Waste collection points and collection systems: A case of computer monitors and TVs*

In the State of Maine in the United States, computer monitors and televisions have been collected by municipalities since 2004. Each municipality has its own method to collect these EoL-products. The data related to these collection methods and the amount of computer monitors and televisions collected was analyzed in an econometric research project.[1] This research showed that if consumers had to pay for the disposal of their EoL-products at a collection point, less EoL-products were collected. However, the more often a collection point was opened, the more computer monitors and televisions were collected per capita. The distance to the collection point was not relevant. If recyclable waste was separately collected (without computer

monitors and televisions) in a municipality, fewer computer monitors and televisions were brought to the collection points. The researchers recommended that the municipalities in Maine cancel the financial contribution for the disposal of computer monitors and televisions, that they increase the hours and days a collection point is open for the convenience of the consumer, and that they consider picking up computer monitors and televisions in homes.

13.3.3.3 *Effects of collection and bring-systems*

Researchers analyzed data from the collection of recyclable waste in the State of Minnesota in the United States.[41] The statistical study focused on the effect of differentiated rates on the collection of recyclable materials (pay-per-bag), public information, and collection and delivery systems. Also the interaction of collection and bring-systems was studied. A bring-system is a system where the consumer brings the (recyclable) waste to a collection point, instead of having it collected at home. The study found that collection and bring- systems were more effective when combined. However, when the collection and bring- systems were implemented separately, both had little impact on the promotion of separated waste collection for recycling.

13.3.3.4 *Collection systems and consumer attitudes*

In an econometric study in Sweden,[5,17] the effect on separated waste collection of social and personal norms, feeling morally responsible, knowledge of separated waste collection, and the set-up of collection systems was researched. Both studies showed that personal, moral and social norms were important factors for separated waste collection if the infrastructure of the collection systems were not very widespread or if the individual had to make more effort to separately collect a recyclable material. Hage *et al.*[17] concluded that publicity for recycling is important to keep morale high for separated waste collection, but this is becoming less important as it is easier for households to separately collect waste for recycling. These findings are in line with research on the convenience and availability of collection systems.[12] If convenience and availability are sufficient, more materials are recycled by weight and by types of recyclable waste. The research of Best and Kneipp[7] shows a similar conclusion: collection systems (opposed to bring-systems) had a positive impact on waste separation behavior; the attitude of consumers however had a small impact. No relationship was

found between the type, size and color of the container and the volume of separately collected material.[24]

13.3.3.5 *Collection systems for mobile phones*

In the United Kingdom (UK) researchers[31] made an overview of the collection systems for cell phones. In the UK, organizations that collect cell phones can be divided into five groups:

1. Shops: including online shops
2. Charitable organizations and NGOs (Non Governmental Organizations)
3. Producers of cell phones
4. Network enterprises
5. "RRR companies": Reuse, Recycling and Repair. These organizations are solely concerned with collecting cell phones, with the intent of reselling repaired cell phones or recycling the cell phones. These RRR companies often give money for a collected cell phone.

Cell phones were collected through mail or courier or collected in stores. Collection via free post was most common. The second most common method was by pick-up by a courier, which is the most common practice of RRR companies. The researchers counted 102 different collection programs. The researchers recommended that collecting organizations focus on collection points in places where people gather, such as libraries, shopping malls and schools.

13.3.4 *Effectiveness of communication*

In interviews at households in the districts of Kensington and Chelsea in London,[35] it was found that more than 50% of the interviewees had a lack of information about separated waste collection, which was the reason to not separate waste. The largest factor contributing to lack of visits to waste collection points was a lack of information about the existence of these points. The effect of the implementation of Robinson and Read's research, the door-to-door personal interviews with households in combination with local and national campaigns, was that in these neighborhoods the most waste was collected and separated for recycling. In the state of Minnesota in the United States, research[41] showed that public awareness resulted in more separated waste collection. The researchers calculated that one dollar per person per year for communications would raise recycling by 2%. In order to make communication effective, communication methods must be

selected that are appreciated by the audience. In a study[28] in Rushcliffe in the UK, 1,000 people were asked for their preference for the best means of communication. The panel indicated a preference for:

- brochures (79%)
- newspapers (34%) and
- personal letters (33%)

In a survey in the town of Rushcliffe, 75% of the respondents indicated that marketing and communications had influenced them to recycle more, and 70% indicated that newsletters were the most effective way of communication about separate waste collection.

In a study at Michigan State University in the United States,[21] students and staff were surveyed about separated waste collection. The survey showed that the respondents had no need for communication about the benefits of separated waste collection. They wanted to know what and how to separate waste and where the collections points were. The researchers concluded that in publicity on separated waste collection the approach should be differentiated to different types of audiences. Students had a need for the promotion of separated waste collection, and the staff had a preference for personal contact on this issue. The researchers recommended placing collection boxes at convenient places in the university, in order to communicate with the public on where and how material is collected for recycling.

13.4 Stimulating Companies

13.4.1 *Introduction*

Companies try to reduce the cost of waste and to be resource efficient for economic reasons. Waste minimization is also an important topic from the QHSE policy (Quality, Health, Safety, Environment) of a company. An example of classic ways a company can reduce waste and recycle is found in a study on the waste reduction in the hospitality industry[10]:

- Minimize waste by
  - the reduction of one-way (single-use) products
  - prioritizing reusable/refillable products.
  - redesigning, re-specifying and/or customizing products and practices in order to use less material that will finally end up as waste.
- Optimize and/or demand longer service life of products.

- Recycle waste and steer waste towards a useful application, for example exchanging useful materials with another company that uses it as a raw material.
- Organize the reuse/recycling loop

Franchetti[13] found that implementing ISO14001 in companies operating in the United States reduced the amount of solid waste. The study showed that in addition to the ISO14001 certification, the total number of employees and the cost of disposing of the residual waste were significant for the reduction of residual waste.

Although companies try to reduce the cost of waste by waste minimization, they do find barriers. Owners of SMEs in the UK were concerned about the environment, but this has not translated into concrete measures.[34] A majority (59%) of the business owners who did not separate waste pointed out that this was due to external factors, while 26% indicated that internal factors were the reason. External factors are not being able to give away the materials or to recycle, that the municipality does not recycle all materials, lack of facilities, the advice on collection containers, government support, the containers and/or space for containers or notification of municipal recycling, the problem of locating a suitable collector and unreliable storage. Internal barriers are cost, lack of knowledge, feasibility, the sorting material, space, time, or the willingness of staff to comply.

The researchers find that by implementing environmental management, SMEs will obtain lasting economic benefits. The researchers therefore recommended setting up training programs for entrepreneurs on environmental management including waste minimization and separation for recycling.

13.4.2 *Training of companies*

In order to train companies in waste minimization and separated waste collection for recycling, different types of trainings were developed.

In the United Kingdom, companies were helped in the prevention and recycling of waste by the Envirowise Program.[15] This program provided practical advice based on existing practices in the industry. Envirowise also had a free help line for businesses. In addition to providing information and assistance, a considerable amount of effort was put into marketing, to help the companies overcome barriers that stopped them taking action. The program was started in 1994 and by 2000 125 million GBP was saved per year by reducing the use of raw materials and by reducing waste.

In a large waste minimization project in the UK focused on agricultural companies, various means were used to transfer knowledge.[3] Of the farms that signed up, 52% were invited through mailings and newsletters, and 26% came in contact with the program by word of mouth. Knowledge was spread by:

- training meetings
- hotline
- auditing quantities of energy and waste, and how to comply with regulations. Part of the auditing was an analysis of the utility company's bills.

The researchers found a strong relationship between the level of a company's commitment and costs saved. Of companies with a strong commitment, on average GBP 945 was saved compared to the average saving of GBP 520.

In the UK, research was conducted on the transferring of knowledge via "business clubs" in the food and beverage sector.[19] The "business clubs" were specially developed for waste minimization. In the "business clubs", training and workshops were given, followed by interactive "reporting back" sessions of the "project champions" in their business. The experience was that in the meetings the following took place:

- cross-fertilization of ideas
- stimulation of innovation, motivation and knowledge and
- encouragement of management strategies.

The disadvantages of this approach to companies were that

- many companies were in the same supply chain, resulting in no exchange of sensitive/confidential information
- the "project champions" knew more of the subject and therefore felt that they "gave more than received", while the other participants in meetings were annoyed about the compliments the project champions got.

WMCs (Waste Minimization Clubs) were set up in the years 2000 to 2005. They were publicly funded and had been a success in several areas in the UK. The WMCs' approach was appreciated by many companies[32] because the companies

- felt encouraged by the progress of other companies
- felt obliged to work towards goals, because of the WMC
- felt reassured that other companies also had the same problems

- got experience in different methods
- had a sense of community

Although WMCs were appreciated by companies, there were also a few issues. Competing companies were not always willing to share information. Meetings were often poorly planned and did not give enough new information and training. In the beginning the costs of membership were found to be high, which caused doubts about participation. Reasons that companies did join the WMCs were, next to cost reduction company image, environmental concerns, sustainable development and the pressure from legislation, from the customers in the supply chain, or from the media.

WMCs resulted in 10% waste reduction in businesses and one or more jobs created for every GBP £2000 invested after 24 months.[9] In one program, the ratio of cost reduction to the cost of joining the WMC was 10 to 1, after 24 months. In another program this was the case for 70% of the companies.

In West Sussex in the United Kingdom 308 (mainly) SMEs participated in WMCs resulting in an annual cost reduction of GBP £214,000 (in 2003) and an annual saving of 1437 tons of residual waste.[2] The companies were helped through workshops, newsletters, audits, subsidies, and a telephone helpline. The companies were approached to join a WMC by:

- presentations at business meetings and trade associations
- presentations with direct mailing followed by a phone call
- direct mailing followed by a phone call
- flyers in the newsletters of local government
- personal contact with references to local government, environmental agencies or environmental programs.
- press releases on radio, in local and national newspapers, and in local government publications.

13.4.3 *Taking products back*

In order to be less dependent on critical raw materials, companies can take products back for:

- re-use
- repair for reuse
- cleaning or "upgrading" with new parts (refurbish)
- re-assembly (re-manufacture)

- retrieving its parts for the manufacturing of new products
- recycling. In many cases the company collects products themselves, so that it can maintain control over its resources.

An example of taking products back are industrial nickel-cadmium and lithium batteries.[8] The company taking back these batteries had financial and strategic reasons, viz:

- The company acquired raw materials themselves for their production of industrial batteries.
- The expertise of recyclers in recovering metals from the batteries and other products already existed and had been proven and monitored in Europe.
- A part of the metal for the production of new batteries had already been purchased from the recycling industry.
- The company experienced price fluctuations of raw materials and therefore wanted more control over their raw materials acquisition.

There were also marketing reasons:

- In the industrial sector, any new restrictions on a product or service is a new reason for further differentiation of the identity of the product. The product distinguishes itself from other products on the market.
- The purchasers of batteries also demanded a responsible processing of discarded products. The company added a new service to their portfolio: recycling of batteries.

Matsumoto[27] listed conditions to be taken into account for the recovery of old products:

- Ownership of the product
- Ability to collect the old products
- Cost advantages of recycling, remanufacturing etc.
- Preferences of consumers
- No conflicts with the market of new products
- Non-economic motives (responsibility towards the environment, strategic control over raw materials)
- Organizational structure of the company, fitting operations on remanufacturing, recycling etc.
- Legislation (e.g. WEEE directive)

Matsumoto used these conditions for setting up a computer model which simulates the market for reuse. The model also includes modeling decision-making of major actors in the recycling market.

To take products back a reverse logistics system has to be set up. In this field, mathematical models and computer models are developed to assess the feasibility and cost implications of take-back operations. For the recycling of WEEE, a model was developed in the United States based on the modeled behavior of actors that make decisions, such as recyclers, producers and consumers. The model can calculate the material flows in a complex recycling network.[30] In another study, a mathematical algorithm has been developed in order to set up a closed cycle in the supply chain.[20] The researchers concluded in the case of battery recycling that by integrating forward and reverse logistics one-third of costs were saved. Another study, using a reverse logistics network model,[29] showed that in the whole operation the remanufacturing process had the largest cost and not the reverse logistics. Mathematical models were used to optimize a collection structure for WEEE in Portugal.[16] The results gave the collector support for strategic expansion with more collection points in the vicinity of the largest sources of WEEE in Portugal.

Conclusion

Waste Electrical and Electronic Equipment (WEEE) is collected for economical, environmental, and public health and safety reasons. This chapter describes how to organize and stimulate the collection of WEEE from consumers and professional organizations (e.g. businesses). These lessons learned could also be applied to other products containing CRMs, such as industrial alloys.

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