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GREEN CITIES AND SETTLEMENTS

UNIVERSITY of OULU
OULUN YLIOPISTO

Best Practices in Municipal Solid Waste Management in Finland

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INTRODUCTION

Wastes are created in nearly all economic activities. Wastes are considered including all objects or substances which the holder discards, intends to discard, or is legally obliged to discard according to Finnish Waste Act. Waste can consider being inefficient use of raw materials and therefore loss of resources. Moreover, wastes can contain dangerous substances or have hazardous properties and therefore they can pollute the environment and cause health hazards. Even the recovery and processing of wastes can produce emissions. (Finnish environment institute 2011a)

The cities in Finland were very small and rural until the end of the 19th century. The amount of waste was minimal because almost everything was effectively recycled. Already then, waste spoiled the wells and caused diseases. Before the 1970s, the waste management in Finland was mainly considered as health issue and, hence, connected with the development of general healthcare regulation. (Nygård 2000). In the early 1980s, waste management became more focused on environmental protection and was administratively separated from public sanitation. (Turpeinen 2005). At the moment, waste reduction is the primary aim of waste management in the Waste Act of Finland. (Sokka et al. 2007)

Municipal solid waste (MSW) usually means all the mixed waste (e.g. kitchen waste, packaging materials, glassware, tin cans) which are handled in the municipal waste management system. Municipal solid waste is produced in households, trade, industries, construction and public and private institutes. Some part of municipal waste is composted, recycled or otherwise recovered as material, some of the waste is incinerated or gasified and the rest is landfilled. (Sokka et al. 2007) When thinking of saving of non-renewable resources, the recovering the waste as material or energy is particularly important. (Finnish Environment Institute 2011a).

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WASTE LEGISLATION

THE WASTE FRAMEWORK DIRECTIVE

Directive 2008/98/EC, the Waste Framework Directive (WFD) presents the basic concepts and definitions related to waste management (e.g. definitions of waste, recycling and recovery). It also defines when the waste is not waste but becomes a secondary raw material (end-of-waste criteria), and what is the difference between waste and by-products. The WFD presents basic waste management principles as it requires that waste need to be managed without endangering human health and harming the environment. EU Member States should follow the waste management hierarchy (figure 1). (European Commission 2012a)

FIGURE 1. WASTE HIERARCHY. (EUROPEAN COMMISSION 2012A)

Prevention is the first in the priority order, then, in descending order, preparing for the re-use, recycling, other recovery and disposal (table 1). (European Commission 2012a)

TABLE 1. THE STAGES OF THE WASTE HIERARCHY. (DIRECTIVE 2008/98/EC)

Stages	Include
Prevention:	Using less material in design and manufacture, keeping products for longer, re-using and using less hazardous materials
Preparing for re-use:	Checking, cleaning, repairing, refurbishing, whole items or spare parts
Recycling:	Turning waste into a new substance or product including composting
Other recovery:	Includes anaerobic digestion, incineration with energy recovery, gasification and pyrolysis which produce energy (fuels, heat and power) and materials from waste; some backfilling
Disposal:	Landfill and incineration without energy recovery

Directive 75/442/EEC on waste has been codified in 2006. Codification means a process of legal texts being revised several times are codified into one new text which then replaces all the previous versions without legal or political. The codified Directive 2006/12/EC was the only legally valid version of the WFD until 2008. In 2005, the Commission proposed revising WFD. This revision updated the waste legislation and merged, streamlined and clarified legislation as well. The revised WFD, Directive 2008/98/EC on waste has been adopted by the Council on 20 December 2008 and it entered into force on

12 December 2008 and the deadline for the transposition of the revised WFD into national legislation of the EU members passed on 12 December 2010. (European Commission 2012b)

Directive 2008/98/EC also enforces the "polluter pays principle" and "extended producer responsibility" (table 2). It also includes recycling and recovery targets to be achieved by 2020 as follows: 50% preparing for re-use and recycling of certain MSW materials and 70% preparing of construction and demolition waste for re-use, recycling and other recovery purposes. The WFD requires that EU Member States have waste management plans and waste prevention programmes. (European Commission 2012a)

TABLE 2 RELEVANT ARTICLES OF WFD (2008/98/EC)

Article 4: Waste hierarchy

- The waste management hierarchy (WMH) is a preference of waste management options
- The currently defined WMH is:
    - Waste prevention
    - Preparing for re-use
    - Recycling
    - Other recovery, e.g. energy recovery
    - Disposal

Article 5: By-products

- A substance or object resulting from a production process, the primary aim of which is not the production of that item

Article 6: End-of-waste status

- Certain specified waste shall cease to be waste when it has undergone a recovery operation and complies with following criteria

Article 8: Extended producer responsibility (EPR)

- An approach where the producers' physical and/or financial responsibility for a product is extended to the post-consumer (waste) stage of a product's life-cycle.

Article 9: Prevention of waste

- By the end of 2011: report on the evolution of waste generation and the scope of waste prevention incl. formulation of eco-design policy
- By the end of 2014: setting of waste prevention and decoupling objectives for 2020

Article 11: Re-use and recycling

- Support or re-use and repair network
- By 2015, setting up separate collection of waste at least for paper, metal, plastic and glass to promote high quality recycling
- By 2020, 50w% recycling of paper, metal, plastic and glass
- By 2020, 70w% recycling of construction and demolition waste

Article 28: Waste management plans

- Analysis of current situation, measures to be taken to support this Directive

Article 29: Waste prevention programmes

- Either integrated into waste management plans or separate programmes

FINNISH WASTE LEGISLATION

The waste policy and legislation in Finland is based on the EU waste hierarchy (Finnish environment institute 2011b). Finnish waste legislation concerns almost all types of waste. Special wastes, e.g. radioactive wastes, are controlled by separate laws. Although the Finnish waste legislation is mainly based on the EU legislation, it may include stricter standards and limits than EU legislation (appendix 2). Moreover, Finland has legislation on some waste related issues that are not included in the EU legislation yet. (Finnish environment institute 2010a) Over 20 decrees have been issued after 1994 after National Waste Act came into effect. Finland has also National Waste Plan which is required by the EU. (Melanen et al. 2002) The general aim of the waste legislation is to support the sustainable development by promoting reasonable use of natural resources and by preventing the harms and dangers for human health and environment caused by wastes. The waste legislation has regulations for the promoting the utilization of wastes, organization of the waste management, preventing of the littering and cleaning of the littered areas. In addition, the legislation includes the regulations for the preventing measures like preventing the formation of waste and the reduction of the amount and harmfulness of waste. The Environmental Protection Act regulates the environmental pollution prevention as well. (HE 199/2010 vp)

The Finnish Waste Act, the Finnish Waste Decree and the Decision 659/1996 of the Council of State cover the transports of wastes within Finland. The professional collection and transportation of waste need to be reported to the National Waste Register kept by the Regional ELY Centers according to the Waste Act. The responsibility of the owner or holder of the waste is to check whether the collector or transporter of the waste has registered his activities with the ELY centre and that the registration covers the waste transportation as well. Moreover, the owner or holder of the waste need to check that the waste collector or the waste consignee have a valid environmental permit issued by the authority, or else the waste or hazardous waste must not be given to the waste collector or the waste consignee. The validity of the permit can be checked with the regional environmental centre remarked in the permit and the permit needs to be shown on request. (Finnish environment institute 2011f)

Until 1979, there was no actual waste law in Finland (figure 2). In 1967, the sanitary law stated that the waste may not cause harm to the human health. In 1979, the first waste act was made. The legislation was about the waste management considering administration, enforcement and financing. Moreover, it was set that waste may not cause harm to environment and that the municipalities are obligated to take care of the local waste issues. (Turpeinen 1995). The new waste law came into effect in May 2012. The most important change in the new waste law is that the partial producer responsibility for packaging is turning to full producer responsibility (i.e. the producers or importers of packagings need to take care of the collection, transportation and utilization of packaging material produced in the households as well). Definition of waste is more accurate and clear since some of waste materials can be classified as by-products which can be utilized easier than waste. (Elinkeinoelämän keskusliitto 2011)

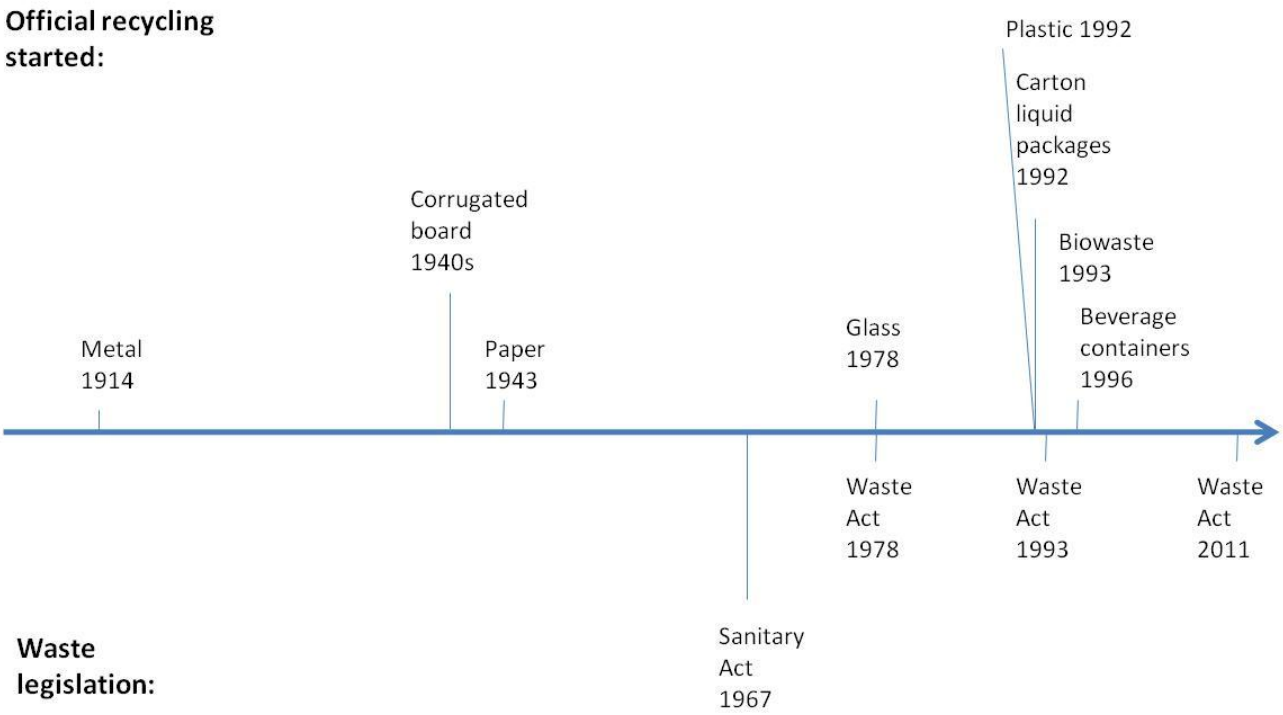

FIGURE 2 TIMELINE OF RECYCLING AND WASTE LEGISLATION IN FINLAND

The ministry of the environment supervises and controls how the Finnish waste legislation is executed. The Finnish environment institute performs research and training, publicizes new ideas and methods, monitors all waste related development issues, and also takes part in establishing new legislation and guidelines related to waste, and also monitors international waste shipments. (Finnish environment institute 2010a).

PRODUCER RESPONSIBILITY IN WASTE MANAGEMENT

Some product groups are under the producer responsibility. Extended Producer Responsibility (EPR) means that the producer has the obligations to the recovery of product and it is prescribed by law. Producers are obligated to finance and organize the collection, preprocessing, recycling, utilization and waste management of their products removed from use. They can take care of this obligation themselves or transfer the recovery obligation to the producer organization (appendix 3-4). (The Environmental Register of Packaging 2011a) Centre for economic development, transport and the environment for Pirkanmaa is the national authority that is responsible for producer registration and other related issues in Finland (except Åland Islands). (Finnish environment institute 2011b) Producers and producer organizations are obliged to submit their details for the national producer data register. (Finnish environment institute 2011c)

The aim of producer responsibility is to encourage manufacturers and importers to think through the whole life cycle of their products. Producer responsibility promotes environmentally favorable product planning, waste prevention, the separate collection and recovery of useful wastes, waste reuse and recycling and the incorporation of environmental costs into product prices. In the context of producer responsibility the producer means the manufacturers and importers of the products or, in the case of packaging, packagers and the importers of packaged products. Producer responsibility covers electronic and electrical appliances; batteries and accumulators; tires from motor vehicles, other vehicles and equipments; cars, vans and comparable vehicles; newspapers, magazines, copy paper, and other comparable paper products and packaging. (Finnish environment institute 2011c).

A packager is a company which is manufacturing a product that uses packaging materials to protect its products (e.g. in production, storing, transport and distribution). Usually the manufacturer of a product is a packer but it may be also the distributor or retailer, if it adds packaging to its products. The importer of packed products is a company that imports products that are packed, and who owns the packed product when it is imported. The reuse means the use of packaging in the same form after cleaning. Finland is among the top reusers of packaging in Europe. The recovery of packaging waste means both the recovery of packaging to make raw material for new products, and the recovery of packaging as energy. Sorting itself or the delivery of packaging to waste collection or sorting sites is not recovery. Recycling is the altering of packaging material so that it can be used to produce a new product. Packaging that is not used anymore is considered as packaging waste. Reusable packaging is packaging waste only when it is taken out of the reuse system. (The environmental register of packaging 2011c) Because of the effective collection and recycling system for packaging materials, the amount of waste packages is very low in Finland: only 84 kg per inhabitants (ca. 200 kg in EU on average). (Suomen keräyslasiyhdistys 2011h)

In 1998 the collection and recovery system of producer responsibility system was constructed in Finland. Problems in producer responsibility system for packages and packaging waste were the coordination with existing municipal waste management system. In addition, producer responsibility system may not lead to waste reduction but increased recycling which need to be changed in future by e.g. encouraging eco-design. (Melanen et al. 2002) The realization of the producer responsibility system has been insufficient in Lapland, especially in case of packaging materials. When there was only partial producer responsibility for packages in Finland (until May 2012), the collection targets for Finland were fulfilled already in southern part of Finland and therefore there was no need to establish proper collection network for packages in Lapland. The situation is assumed to be changed with the new Waste law. (Lapin ELY 2011)

WASTES GENERATED IN FINLAND

According to the statistics, it seems that the amount of waste in Finland is increasing. In 2004, the amount of waste was about 66 million tonnes (excluding the manure used in agriculture and logging waste left in the forest), in 2007, about 74 million tonnes (Suomen ympäristökeskus 2012), in 2008, about 80 million tonnes (HE 199/2010) and, in 2009, almost 85 million tonnes (Suomen virallinen tilasto 2011a). Most of the waste is produced in the construction, mining and quarrying sector (figure 3). The majority of the construction waste is mineral waste whereas the mining and quarrying sector generates mostly waste stone, ore dressing sand and excess soil. (Finnish environment institute 2011a)

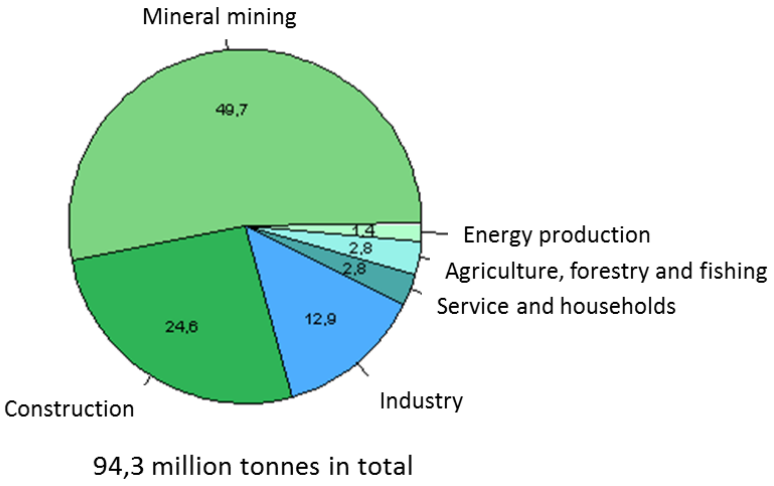

FIGURE 3 AMOUNTS OF WASTE BY SECTOR (MILLION TONNES) IN 2010. (SUOMEN VIRALLINEN TILASTO 2012)

MUNICIPAL SOLID WASTES

Amount of MSW seemed to be rising quite steadily for many decades till the year 2008 (figure 4). In 2009 about 2,56 million tonnes of MSW were collected (Suomen virallinen tilasto 2010a) which was 7,4 % less than in 2008 (Suomen virallinen tilasto 2011c).

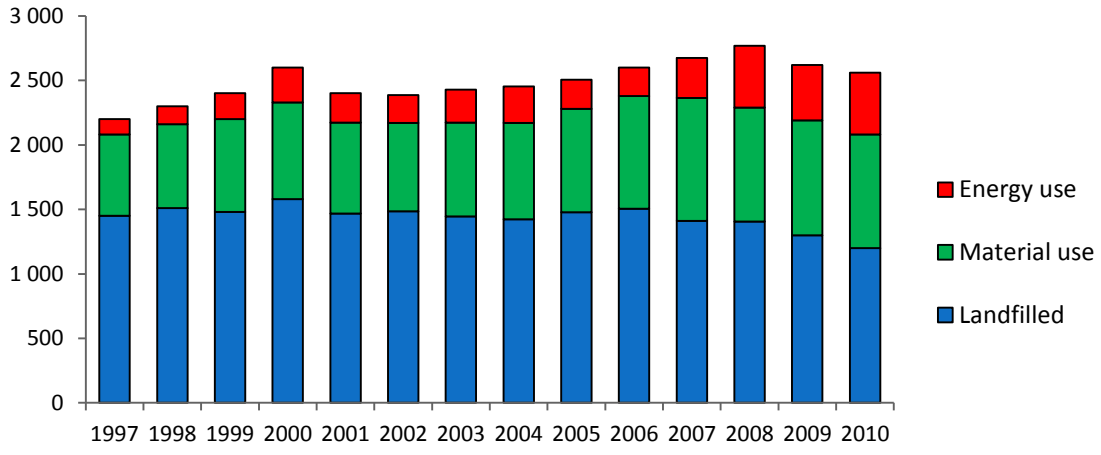

FIGURE 4 AMOUNTS AND TREATMENT OF MUNICIPAL WASTE DURING 1997-2010 (SUOMEN VIRALLINEN TILASTO 2011C)

Altogether 1,13 million tonnes municipal waste were landfilled in 2009, which was 16 % less than in previous year (Suomen virallinen tilasto 2010a). Altogether 478 kg of municipal waste per year per inhabitant was produced in 2009 in Finland (Suomen virallinen tilasto 2010b) and, in 2010, the amount

of municipal waste produced and landfilled has still slightly decreased (figure 4) so that the amount of municipal waste per inhabitant was then 470 kg (Suomen virallinen tilasto 2011d). About half of MSW was foodstuff, wastepaper and cardboard (Suomen virallinen tilasto 2010b, figure 5) and about 80 % is biodegradable material (HE 199/2010 vp).

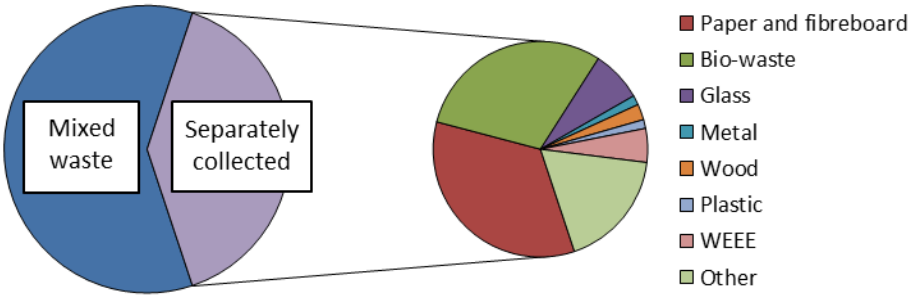

FIGURE 5 FRACTIONS OF MSW IN FINLAND IN 2010 (SUOMEN VIRALLINEN TILASTO 2011D)

About 60 % of MSW is generated by households and the rest is produced in the service sector (Finnish environment institute 2010a). In addition, the share of households and public sector is estimated to be that 86 % is from households and 14 % is from public services (table 3, Ympäristöministeriö 2010a).

TABLE 3. ESTIMATES OF MSW AMOUNTS PRODUCED IN HOUSEHOLDS, PUBLIC SERVICES AND PRIVATE SERVICES (KAPLAS 2009 IN YMPÄRISTÖMINISTERIÖ 2010A)

Waste sector	Households and public services (tonnes/a)	Private services (tonnes/a)
Mixed waste	1 199 000	376 000
Paper and cardboard	258 000	132 000
Bio-waste	156 000	121 000
Waste wood	3 000	29 000
Plastic	24 000	25 000
Others and unclassified	215 000	59 000
Total	1 854 000	742 000
All in total	2 596 000	

HAZARDOUS WASTES

According to Finland's Waste Act (1072/1993) hazardous wastes are wastes which could harm the environment or be a health risk due to their chemical or other properties. Hazardous wastes types are classified in a list of hazardous and general waste types which are defined in connection with the Ministry of the Environment decree 1129/2001 which is again based on a similar list defined by the European Community. Local authorities are responsible for the recovery and treatment of hazardous wastes produced in homes, farming and forestry, if the quantities are not excessive. The packing and labeling of hazardous wastes is controlled according to special legislation. Hazardous wastes may only be transported to landfills which are equipped to treat them. (Finnish environment institute 2011e)

Several Finnish firms are specialized in the treatment and recovery of hazardous wastes. The national hazardous waste facility Ekokem Oy is jointly owned by the state, local authorities and industry. It treated ca. 10% of the hazardous waste produced in Finland in 2003 and it is equipped to treat all the common

hazardous waste. Other facilities have specialized in the treatment of specific types of hazardous waste. 1,3 million tonnes of hazardous waste was produced in Finland during 2003. 57% of hazardous waste was transported to hazardous waste landfill sites and 22% was recovered as material or energy. (Finnish environment institute 2011e).

EVOLUTION OF WASTE MANAGEMENT IN FINLAND

WASTE AMOUNTS AND COMPOSITION

After the wars, the urbanization and fast growth in gross domestic product speeded up the production of municipal waste (Turpeinen, 1995). In the 1950s, 370 000 inhabitants of Helsinki produced 320 000 cubic metre of municipal waste to landfills per year. The increase in the amount of waste was faster than the growth of population. In 1963, it was estimated that during the past 15 years, the amount of inhabitants in Helsinki increased 1,32-fold, whereas the amount of municipal waste has increased 2,35-fold (Nygård 2000).

The amount of MSW per person increased 4-fold and total MSW production 5-fold from 1960 to 1990 (figures 6a and 6b). However, it is estimated that produced amount of municipal waste was 200kg per inhabitant in the 1960s and 400kg per inhabitant in the end of 1970s (Tommila 1984) which are higher than in studies of Sokka et al. (2007). In both figures the increasing trend is obvious.

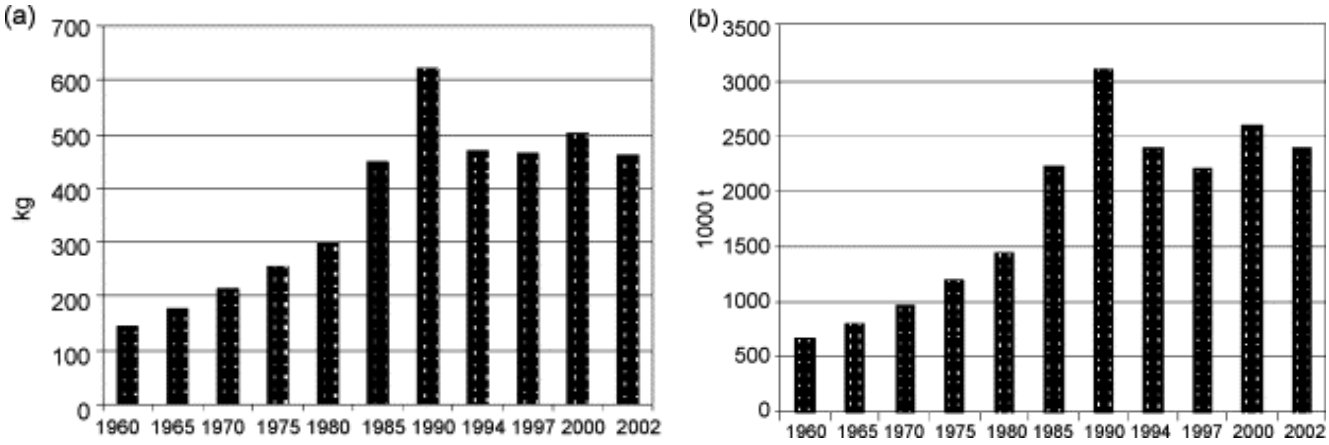

FIGURE 6 (A) MSW GENERATION (KG/PERSON/YEAR) IN FINLAND BETWEEN 1960 AND 2002 AMD (B) TOTAL MSW IN FINLAND (100/YEAR) (SOKKA ET AL. 2007)

In 1960-1980 increase in MSW generation remained stable (3–4% per year) but in the 1980s, the growth rate was already about 7% per year. In 1990-1997 municipal waste production fell, then increased between 1997 and 2000 but declined again from 2000 to 2002. The annual change in population was quite low, less than 0.6%, all the time. Zacarias-Farah and Geyer-Allély (2003) found that the generation of municipal waste per capita in OECD countries has increased by 22% from 1980 to 2000. In Finland the increase was over 60% (despite the decrease in production of municipal waste since the 1990s) which may be due to the high economic growth rate of the 1980s in Finland. Walsh (2002) found out that the generation of municipal waste per capita in New York City was about the same at the beginning and at the end of the 20th century but there was strong fluctuation during the decades. Per capita production of municipal solid waste was in the highest in 1940 (940 kg/inhabitant/year), then at the lowest in the 1960s (320 kg/inhabitant/year) and remained constant after the 1980s (430 kg/inhabitant/year).

According to the European Environment Agency's (2005) studies in 29 European countries (1995-2003), in the Eastern and Central European countries municipal solid waste production has stabilized but in the Western Europe countries it continues to grow. Municipal solid waste generation seems to have stabilized in the 21st century in Finland but there is no clear explanation why. (Sokka et al. 2007) The most recent statistics show even decline in the amount of produced municipal waste since 2008 (Suomen virallinen tilasto 2010 a) which continued in 2010 being 470 kg per inhabitant (Suomen virallinen tilasto 2011d).

The composition of MSW changed during the period 1960s-1990s in Finland. The proportion of paper and cardboard declined from 50–70% (in the 1960s and the 1970s) to 40–50% in the 1990s maybe because other packaging materials (e.g. plastic) replaced paper. The proportion of the organic waste fraction has increased from 10–20% (in the 1960s) to 30–40% (end of the 1990s) and the share of plastic waste increased to about 10% in the 1990s. Earlier municipal waste contained even 20% of ash, sand and other non-combustible materials but their proportion decreased to 5–7% by the end of the 1990s because of transition to district heating, electricity and oil in the heating of residential buildings. (Sokka et al. 2007). The same kind of change was seen in New York from 1920 to 1990, as the mass fraction of fuel ash reduced and amount of organic waste, paper and plastic increased markedly (Walsh 2002).

WASTE TREATMENT METHODS IN THE PAST

In 1904, municipal waste collection system, based on barrel and cement containers, was established in Helsinki. In the 1920s, excrements and ash were collected separately for fertilization use in some parts of Helsinki. Later on, the target of sorting was to separate waste on three different groups: food for pigs, material for fertilization use and other kinds of wastes. (Turpeinen, 1995) In the 1950s, waste furnaces were common in residential buildings but due to the odour and small particles, they were abandoned in the 1970s (Nygård 2000).

In Finland industrialization started at the second half of the 20th century with urbanization (Nygård, 2000). Low population density and long transportation distances affected the waste management and, hence, resulted in lots of small landfills throughout the country. In the 1970s it was suggested that the amount of landfills should be reduced and the use of existing landfills should be more effective. Moreover, the establishment of landfills became licensed and they needed to be planned properly. (Turpeinen 1995) The share of landfilling decreased from about 95% to 60% from 1960 to 2002 (figure 7). (Sokka et al. 2007) In 1990, there were 480 municipal landfills but only 110 in 2009 (Hänninen 2009).

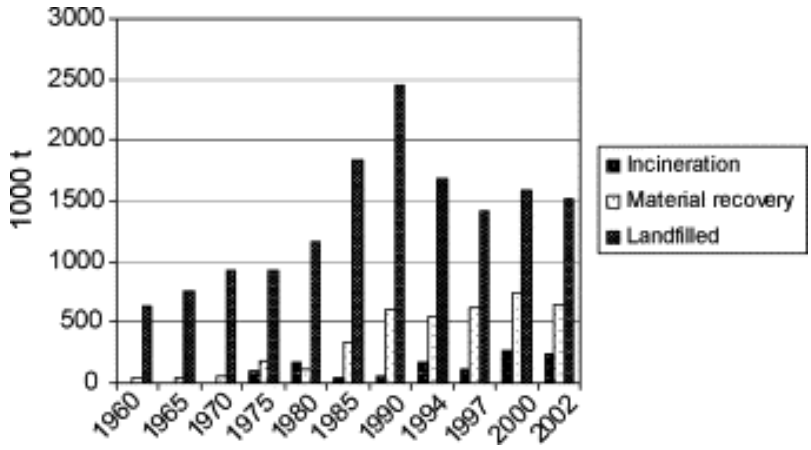

FIGURE 7 MSW DISPOSAL METHODS (1000 TONNES/YEAR) IN FINLAND BETWEEN 1960 AND 2002 (SOKKA ET AL. 2007)

Although the main waste disposal method was landfilling until the 1990s, there were a few serious attempts on both incineration and composting (Tommila, 1984) such as the building of a new

incineration plant in Kyläsaari, Helsinki in 1962. Already at the beginning of the 20th century there were several trials to separate and compost bio-waste, but without success. In 1959, composting plant for waste was established in Helsinki and later on in Turku. In 1965 it was obvious that the costs of composting were too high and the product of the composting plant was not clean enough because of the metal, stones, glass and fabric in the waste material used for composting and the composting plant in Helsinki were closed. The incineration plant was also closed due to environmental reasons (Turpeinen 1995). In the 1990s sorting of bio-waste was more effective and a new composting plant was established again. (Nygård 2000)

The incineration of the municipal waste was started in the large cities of Europe at the end of the 20th century to improve the hygiene of the cities. At that time, the effects of flue gas were not known and new plants were established. However, after the harmfulness of flue gas was recovered in the 1980s, the building of the new incineration plants was stopped and some of old ones were closed in Finland. EU directives have regulated the emissions of the waste incineration to the very strict level which caused the closure of some of the old waste incineration plants in Finland. After that, the purification techniques of flue gases have developed fast and amount of emissions has declined efficiently. Many new waste incineration plants have been built in the 21st century. (Jätelaitosyhdistys 2011a).

REASONS FOR THE CHANGES IN THE AMOUNTS OF WASTE

It is hard to estimate the exact amount of waste produced during the last decades due to lack of reliable historical data. (Melanen et al. 2002). The strong increase in the amount of MSW from the 1960s to the 1970s may partially be due to increase in the use of packaging material and decrease in the amount of waste furnaces (Tommila 1984). Other reasons for increased amount of wastes are e.g. higher living standard, use of disposable packages and the short operating life of goods (Hänninen 2009). The amount of waste usually increases as the standard of living of inhabitants becomes higher (European Commission 2011). The study of Sokka et al (2007) indicates that the relationship between gross domestic product growth and municipal solid waste production is not distinct because MSW production is not as directly proportional to gross domestic product as is often expected. The severe economic depression had a strong reducing impact on the production of municipal solid waste in the early 1990s. After 1994 the annual increase in per capita gross domestic product was over 3%, hence, obviously improved policy measures played a role in the reduction in the growth rate of municipal waste. Moreover, in 2009, consumption expenditure of households decreased 1,8 % and net sales of the service sector decreased 7,5 % in Finland (Suomen virallinen tilasto 2010b) which may partially explain the decreased amount of waste.

According to Sokka et al. (2007) the new ordinances on waste have achieved an increase in the level of recovery of waste but they have not been as efficient at encouraging waste reduction. Municipal waste charge and national waste tax has been quite encouraging as economic instruments. (Melanen et al. 2002) Packaging policy naturally affects waste generation and, hence, any changes in the type of packaging (i.e. using refundable packaging) have an impact on municipal waste production. Over 2/3 of the packaging is reusable in Finland and therefore less packaging waste is generated than in the EU on average (Environmental Register of Packaging PYR Ltd., 2011d, appendix 1, tables 12-16).

DEVELOPMENT OF RECYCLING IN FINLAND

METAL

Metal recycling has a long history in Finland because metal has always has been a valuable material (Romukeskus 2011a). The **Romukeskus Oy** wholesale company was established in 1940 during the Second World War. At that time there was controlled economy which included also scrap selling in Finland. Scrap was important raw material which was not allowed to export and also domestic market was controlled by the purchasing monopoly of industry. The supervision of the interests of scrap sellers got them to cooperate and they established Suomen Romukauppiaiden liitto (**The Finnish Scrapdealers Associaton**) and wholesale firm Romukeskus Oy. For many years Romukeskus Oy was the only wholesale firm for the scrap sector in Finland. It negotiated with the industry and regulation authorities for the prices of scrap and took care of the bulk selling of the domestic scrap metal as raw material to industry. The wholesale firm confirmed the bargaining position of scrap dealers and it made the collection of scrap more effective. (Romukeskus 2011b).

After the war, the amount of scrap material collected by Romukeskus increased in Finland after the war since there was a continuous need for iron scrap caused by industrialization. In the early 1960s Romukeskus was delivering 90% of iron scrap to industry and in 1963 the company delivered over 100 000 tonnes of scrap. Energy crisis and the increase in the price of raw materials affected the scrap sector as well. Although the world market prices were increasing, the price of scrap in Finland decreased since there was export ban in Finland. This caused the price war between the industry and scrap dealers in 1973-1974 and new wholesale firms for the scrap sector were established. In the 1990s markets were freed and export ban was dissolved so scrap material was finally exported in 1991.

Occasional shortages of domestic raw material in Finland caused importing of scrap iron from Russia. On the other hand, the export of unneeded scrap iron was developed. The trade of nonferrous metals has increased rapidly and most of the material is exported. (Romukeskus 2011b) Nowadays, because of EUs regulations, recycling is more and more important issue for both industry and private person (Romukeskus 2011a).

Nowadays Romukeskus Oy is an organization of selling, purchasing and marketing for independently working scrap dealers. Romukeskus has over 50 dealers countrywide and its turnover is over 60 million euro in 2010. (Romukeskus 2011c) Romukeskus is dealing with bulk selling of scrap steel and cast iron, dealing and exporting of nonferrous metal scrap (copper, aluminium, brass) and exporting and importing of scrap steel (Romukeskus 2011a).

Kuusakoski company was established in Viipuri, Finland in 1914 as scrap company based on recycling. The principle of Kuusakoski is to keep irreplaceable natural raw materials in production by recycling and refining metals into new raw materials for use in industry. (Kuusakoski recycling 2011a) Most active times of growth were the time of industrialism after the wars and internationalization in 1970-1990s. In the 21st century Kuusakoski has increased and developed the delivery network. The quality of metal is not so important, since Kuusakoski accept steel, copper, aluminum, precious metal and mixed metal. Metal can be recycled several times. All household metal, like food cans and roofing iron, sauna stoves, mopeds, bikes, toys, wire fencing kettles, of all sizes and/or ages can be recycled. (Kuusakoski recycling 2011b).

Nowadays Kuusakoski is an international company providing recycling services. Kuusakoski is the leading recycler of metal-based products in northern Europe and one of the largest suppliers and refiners of recycled metals in the world. Kuusakoski provides recycling services for customers in industry, trade,

offices, construction or consumers. Kuusakoski collects all recyclable materials from customers, processes and makes them into recycled steel and aluminum. Kuusakoski design, manufacture and deliver recycling machinery and equipment for customers in industry. (Kuusakoski recycling 2011a).

PAPER

The shortage of paper in Germany launched the recycling and exporting of paper in Finland. Ruben Liebkind, an export agent in 1920-1930, delivered up to 10 000 tons of recycled paper per year. The very first sorting plant for recycled paper was established to Länsisatama in Helsinki by Kurt Pilack. In the 1930s non-profit organizations collected e.g. metal, rubber and paper as voluntary work. During the war years, paper was collected only from major sources like printing houses, paper converting mills, companies using packages and public sector. The overall recycling rate of waste increased after the war since there was shortage of raw materials. (Paperinkeräys Oy 2011a)

Jätekeskus Oy was established in 1943 for the collection of paper and acquisition of raw material. There was four forestry companies and one private member, Berndt Relander, as founder members. The name of Jätekeskus Oy was changed to Paperinkeräyskeskus Oy in 1961 and to Paperinkeräys Oy in 1965. During the peacetime, the collection of recovered paper was expanded to the households as well. The Ministry and Foreign trade licence office invented to offer the reward for collected material to motivate people to collect the paper. The first collection campaign with rewards like candy was launched in 1947. During the same year Jäte-Joonas campaign with reward like candies, sugar and rice was introduced. 5400 tonnes of paper was collected in 1947. At the beginning of the 1950s Swiss and German clocks were used as rewards. In the 1950s silverware and in the 1960s children's toys, e.g. assembly kits and dolls, were used as rewards whereas English and Swedish language course material was delivered as a reward in the 1960s. Schools were awarded by providing e.g. televisions and other devises, and class libraries and films. There were 5400 collection points for paper in 1965. (Paperinkeräys Oy 2011a).

The use of collection rewards for paper was very common until the early 1970s, after which the collection was organized by professional collection companies. There were collection containers for properties in urban areas and regional collection containers in sparsely populated area. Collection of office paper increased after 1976 when G. A. Serlachius (nowadays Metsä Tissue Oyj) founded the deinking plant in Mänttä. At the beginning recovered paper was used only for carton interlayer, saturating felt and packing paper. In 1978 deinking plant Keräyskuitu Oy was established in Kotka, after which recovered paper was used for raw-material of newspaper as well. In 1992 the first experiments of collection of milk- and juice carton in East-Helsinki and of carton packaging in Salo was launched. The first Kiertolaari-containers were introduced in 1996. In 1997 Paperinkeräys Oy received ISO 9002 quality certificate. In 1998 Council of state made a decision for collection and recycling of recovered paper. (Paperinkeräys Oy 2011a)

FIBRE PACKAGES

Recycling of board started already in the 1940s and it is valuable raw material for cardboard industry (Suomen aaltopahviyhdistys 2011a). Corrugated board consists of wood fibres and starch size. Old corrugated containers are very valuable and wanted raw material (Suomen aaltopahviyhdistys 2011b). Suomen Aaltopahviyhdistys ry (SAPY) is organization funded in 1963 by Finnish corrugated board factories (Suomen aaltopahviyhdistys 2011c). SAPY has promoted the collection of corrugated cardboard together with trade and collection stores already since the beginning of the 1990s and the amount of landfilled cardboard material has therefore decreased markedly. (Suomen aaltopahviyhdistys 2011d) The first experiments of sorting and collection of carton liquid packages was carried on in 1992 to Helsinki and in 1994 to Hämeenlinna. Experiment was successful and the collection percentage was 43% (Lettenmeier 1994).

GLASS

The collection of glass was launched in Finland in 1978, when committee for glass collection was founded in Riihimäki. The committee consisted of the city of Riihimäki, company Riihimäen Lasi (Riihimäki glass) and waste management company Häti Ky. In the beginning there were 3-4 containers which located near the shops. In 1978, collection of glass was started in Karhula by company Karhulan Lasi Oy (Karhula glass). The collection started well and people participated actively. Impurities in the collected glass (e.g. metal parts in bottles) caused some problems in the utilization of the glass. In the 1980s, small purifying plants were founded in Riihimäki and Karhula, but the results of purifying were not very good. Collection rates increased yearly so transporting and financing caused trouble. In 1995, Finland joined EU, after which EU set targets for the utilization of packaging materials. For glass the target was 48% which was exceeded. In the same year the modern glass purifying plant (operated by company Suomen Uusioaines Oy) was launched in Forssa. (Suomen keräyslasiyhdistys 2011a) It was more specialized and efficient so the use of glass expanded into new areas. (Uusioaines Oy 2011a).

In 2000 Finland was the second largest glass collecting country after Switzerland. (Suomen keräyslasiyhdistys 2011a) In 2001 the collection rate of glass was ca. 72% in Finland of which ca. 49% was utilized (EUs objective 48%). (Suomen keräyslasiyhdistys 2011b) As the importing limits of alcoholic beverages were removed, the amount of packing glass outside of statistics increased. Earlier the collection of glass was organized by municipalities and since 1990 Alko has accepted bottles it has sold. In 2005 the collection of glassware was organized both by municipal organizations and the reward system. Problems for collection are still caused by impurities in collected glass material and increasing costs, especially in municipal collection. (Suomen keräyslasiyhdistys 2011a)

BEVERAGE CONTAINERS

Traditional glass bottles became refundable in the 1950s. Bottles are refilled so they can be reused several times (Palpa 2011a). Beverage cans came to the Finnish market in 1996 and recyclable plastic bottles in 2008 (Palpa 2011b)

PLASTICS

The history of the use of plastic started in 1868 when plastic replaced the use of ivory. In Finland, the first company producing plastic was Sarvis Oy in 1921. Hartsiteollisuus Oy started in 1932. The word “muovi” was introduced in 1949. Pekema Oy was started in 1969 and Neste Oy expanded to plastic production in 1971. In the 1980s there was a strong increase in the using of plastic. In 1992, Suomen Uusiomuovi was established and the utilization of used plastic increased. In 2001 Finland accomplished the target of 15 % in plastic recycling set by EU. In 2006 energy use of plastic nearly vanished in Finland and the recycling of plastic as material became more important. In 2008, waste plastic was used in new waste power plants again and the recycling of PET bottles was launched. (Suomen uusiomuovi 2009a).

The recycling of plastic for use as material is not very common. (Hänninen 2009). In the 1990s there were demonstration projects in several localities about the separate collection of unrefundable plastic funnels and bottles. The collected plastic was not clean enough for material use manufacturing new plastic products so after those experiments, the unrefundable plastic was used mostly for energy production. (Suomen uusiomuovi 2009b) In addition, the municipal collection of plastic was demonstrated in the 1990s in Porvoo, Lahti, Helsinki, Turku, Kokkola and Kangasala. (Lettenmeier 1994) Nowadays some companies are collecting plastics (Hänninen 2009).

BIO-WASTE

Composting has always been a very common method of taking care of bio-waste in rural areas. (Lettenmeier 1994). Pioneer in the separate collection of bio-waste is Pääkaupunkiseudun yhteistyövaltuuskunta (YTV). It started the collection experiments in the 1980s (Hänninen 2009). First bio-waste collection and composting experiments in Finland were in 1988 in Vuosaari, Helsinki, in 1982 in Joensuu, in 1990-1991 in Espoo and in 1993 in Tampere. The results of these experiments were positive. (Lettenmeier 1994). The recycling rate of bio-waste in Tampere was 20-60% depending on the type of apartment house. Also the quality of sorting was good (Nieminen & Isoaho 1995) YTV launched the actual separate collection of bio-waste in 1993, after which the other municipalities started separate collection due to legislation. Production of bio-waste is quite remarkable, 10-15 liters per family in one week (Hänninen 2009).

ORGANIZATION OF MUNICIPAL WASTE MANAGEMENT IN FINLAND

Waste management in Finland is a basic service affecting the health and environment of the citizens and it is part of the infrastructure of the municipalities. Waste management consists of collection, transportation and treatment systems organized by municipalities, companies and organizations with producer responsibility (figure 8). Municipalities are obligated to organize municipal solid waste management (MSWM). (Jätelaitosyhdistys 2011b) The municipality may organize MSWM by itself, or together with other municipalities. Regional joint-stock and federation of municipalities waste stations have been founded and they can work effectively and have resources for development work according to tightened environmental demands. There are currently 40 regional waste management firms providing services to 350 municipalities and 4,8 million people in Finland. (Finnish environment institute 2011d) Collecting, transporting, handling and utilization services organized by waste companies are countrywide. Municipal waste companies are cooperating with industry and producer organizations. Waste stations may use competitive bidding and buy main part of their services from private companies according to the public procurement method. (Jätelaitosyhdistys 2011b)

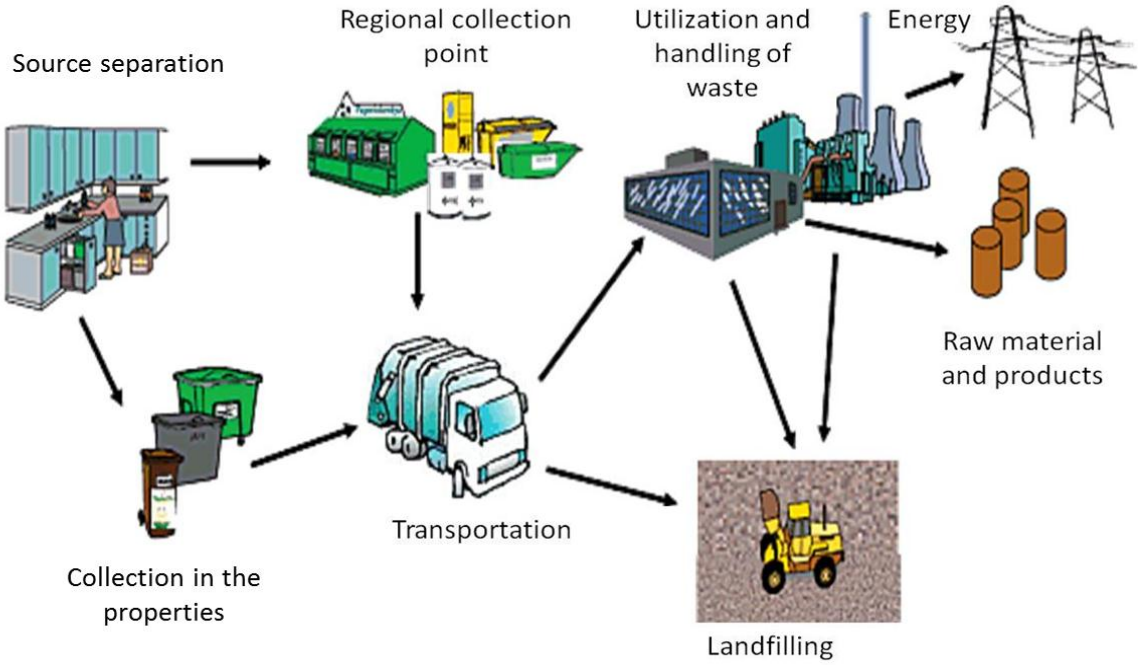

FIGURE 8 WASTE MANAGEMENT SYSTEM IN FINLAND (KUNTALIITTO 2006)

SORTING

Efficient sorting of waste in households and companies helps to collect the usable materials for example to composting or for recycling. It is possible to improve the recovery of MSW by developing sorting and considering the recycling of packaging waste already at the planning phase. Energy recovery is seen as a complementing part of material recovery in many European countries, as in those countries both material and energy recovery is on a high level. (Jätelaitosyhdistys 2012a)

COLLECTION

Property-owners and housing companies are obliged to organize waste collection points and containers for household waste and the producers of waste should take their waste to these collection points

(Finnish environment institute 2011d). Different types of wastes are separately collected to make handling and utilization easier. In addition, it is reasonable to collect waste which still has market value, e.g. metal and paper. Municipal waste companies have organized collection points for the collection of recoverable waste countrywide. In addition, recoverable materials are collected from properties (if collectable materials are produced enough when considering economic and environmental reasons) and by organizing collection events. Collection of hazardous waste is comprehensive in Finland as well. (Jätelaitosyhdistys 2011c) Most commonly, paper, glass, organic wastes, hazardous wastes and cardboard are separated but energy waste for incineration and metallic wastes are also collected separately in some localities. (Finnish environment institute 2011d) Almost all citizens are able to use the separate collection of paper, glass and hazardous waste. There is separate collection for metal in ca. 96% for cardboard in ca. 97%, and for bio-waste in 68% of Finnish municipalities (Hänninen 2009).

Collection containers can be surface collection containers or deep collection containers. The more traditional way to collect the waste is to use the surface collection containers (figure 9). Usually the size of bio-waste container is 140 liters or 240 liters and for other types of wastes 240 liters or 600 liters. Different colors in containers are used for different types of wastes. Usually town houses and apartment houses have their own containers for paper, card board, metal and glass, but carton liquid packagings, batteries and hazardous wastes are collected to regional collection points. Single family houses usually have containers only for bio-waste and dry waste. Usually containers are emptied once a week (depending on the waste fraction and waste regulations) by using garbage trucks. Problems with surface containers are that they are quite small but they still need relatively large space (Hänninen 2009,).

FIGURE 9 SURFACE COLLECTION CONTAINERS (LASSILA TIKANOJA 2012)

Deep collection containers, like Molok and Uppo, are partially below the ground with the lifting bag made of a strong textile material inside the container (figure 10). Deep collection containers are much larger than surface collection containers and they only need to be emptied every other week (or every 1-6 weeks) depending on the waste type and waste regulations. The size of the container for bio-waste, glass and metal is 1300 liters, for paper and card board 3000 liters and for dry waste 5000 liters. Bags inside the containers are emptied by the truck by lifting the bag out of the container and then releasing the mechanism at the bottom of the bag. Usually the costs of the using of deep collection containers are lower since they don't need to be emptied so often. Moreover, they don't need so much space aboveground. (Hänninen 2009, Molok ltd 2009)

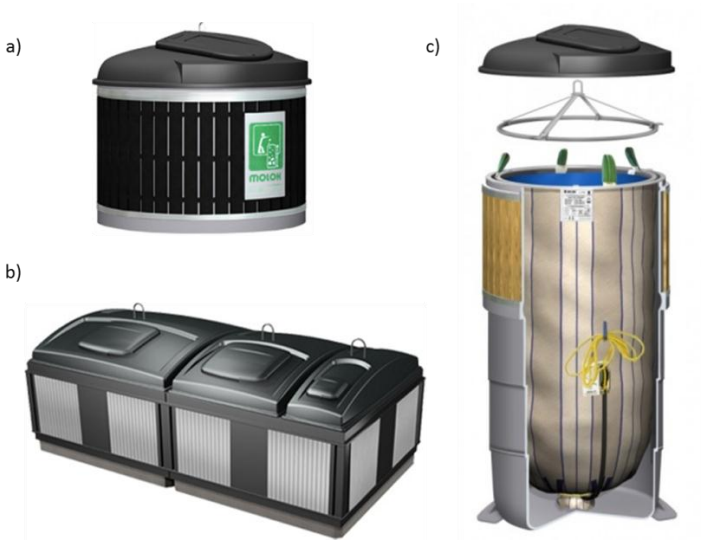

FIGURE 10 DEEP COLLECTION CONTAINERS (MOLOK LTD 2009)

Usually, properties of households are using waste containers of 240 (single family houses, small terraced houses) and 600 liters (large properties), whereas properties of public sector and regional collecting points have containers of 600 liters or even large-scale containers. The amount of mixed waste produced in households and in public sector is estimated to be 1,2 million tonnes yearly. In total, 95 % of mixed wastes is collected by using manually moveable containers and only 5 % is collected by using large-scale containers (e.g. deep collection containers). (Ympäristöministeriö 2010a)

TRANSPORTATION

Local authorities usually organize waste transportation through agreements with private waste companies, since most municipalities do not have waste collection vehicles of their own. (Finnish environment institute 2011d) Municipal solid waste management requires effectively organized logistics i.e. from collection and transportation to handling and utilization. Most of the waste transportation companies are selected by using of competitive bidding but some of the properties use contractual waste transportation by making the contract with the transportation company directly. The using of competitive bidding may lower the cost on transportation, since the municipalities can buy transportation services in bulk and, as major customers, they have advantage over other competitors. (Jätelaitosyhdistys 2011d)

If the municipality is organizing the waste transportation, it can set the price of the transportation for the owner of properties. This system was in use in 33% of municipalities and it covered 50 % of the citizens in 2006. The owner of property may use competitive bidding and select the contractual transportation with the waste company directly (in about 47 % of municipalities and 40 % of the citizens). The rest of the municipalities are using both systems. (Ramboll 2008, 5)

WASTE TREATMENT

Municipalities are obligated to organize the utilization and treatment of the waste that they are responsible for. All the waste that municipalities are responsible for, including the wastes from contractual waste transportations, needs to be transported to the adequate place organized by municipalities for their utilization and treatment. (HE 199/2010 vp, 20). Waste treatment means recovery or disposal operations, including preparation prior to recovery or disposal. In essence, it involves converting the waste material to more harmless or more useful form, considering future utilization. Waste can be treated by biological, mechanical and thermal processes. In Finland, waste

treatment is centralized in large regional treatment centers where the treatment can be done effectively and economically. All the centers have processes for different waste types and disposal places for the wastes that are not recoverable. (Jätelaitosyhdistys 2011e)

In biological treatment, the bio-waste is decomposed by using composting or anaerobic digestion to more harmless and safer form and that can be used in soil improvement. Biogas produced in anaerobic digestion consists mainly of methane which can be used as a source of energy. Biological treatment is used for municipal bio-waste and sewage sludge. For large amounts of bio-waste there are treatment facilities where the bio-waste can be treated in closed reactors. (Jätelaitosyhdistys 2011e)

LANDFILLING

Mechanical pre-treatment, e.g. crushing and screening is often used when there is a need to separate or reshape different fractions of waste before utilization. The method is used for the processing of MSW to recovered fuel (REF). Waste fractions that cannot be utilized are transported to landfills for final disposal. As the degradation of biodegradable wastes generates greenhouse gases, the landfilling of bio-waste will be banned in future and only inorganic wastes such as ashes from energy production can be placed in landfill. (Jätelaitosyhdistys 2011e) The number of landfills has been declining strongly during the past years because of the strict requirements for the base structure of landfills (table 4, HE 199/2010 vp)

TABLE 4. NUMBER OF LANDFILLS IN FINLAND IN 2009 (HE 199/2010)

Landfills in Finland in 2009	
Landfill for soil	167
Landfill for hazardous waste	27
Landfill for permanent waste	37
Landfill for regular waste (inc. municipal waste)	137
Other landfills	29
Total	397

RECOVERY RATES OF WASTES IN FINLAND

Waste recovery rates vary depending on the waste sector. In 2009, the mineral and wooden wastes and metal scrap formed the largest group of the total amount of wastes in tonnes recovered as material. The majority of the mineral wastes are landfilled and wooden wastes are mainly used as energy. Almost all metal scrap and glass are recycled. (Finnish environment institute 2011a) In 2004-2007, most of the wastes were landfilled but the portion of landfilled waste has decreased during 2004-2007 from 63,2 % to 59,5 %. The share of wastes used as a material did not change notably during the same time period (about 28.4 %) but the portion of wastes used as energy increased from 8,2 % to 12 %. (Suomen ympäristökeskus 2012).

In 2009, about 54 % of municipal waste was recovered as material or as energy (figure 3) (Suomen virallinen tilasto 2010b). This amount is extremely high since the recovering rate is usually about 40 per cent of the total amount of generated wastes in Finland. (Finnish environment institute 2011a). The recovering rate of municipal waste has increased because of improved sorting and separate collection. (Finnish environment institute 2010a) In 2010, the recovery rate of waste as material or as energy was even higher, 55 % (table 5), but it is noticeable that it was not due to improved recycling since the amount of material use decreased strongly and the energy use of waste increased. The energy use of waste material is now 22 % of the municipal waste produced yearly and it has increased 2,3 fold in four years. The amount of collected waste paper and cardboard decreased significantly (ca. 20%) in 2010, whereas the amount of waste electronic and electrical appliances (WEEE) waste has increased steadily to be now five-fold compared to the beginning of the last decade. (Suomen virallinen tilasto 2011d)

TABLE 5. MSW IN 2010 IN FINLAND (TONNES) (SUOMEN VIRALLINEN TILASTO 2011D).

	Amount of waste		Treatment		
	Tonnes	Percentage	Material use	Energy use	Landfilling
Mixed waste total	1 519 020	60.3 %	42 889	373 436	1 102 695
Separately collected of which	1 000 984	39.7 %	779 263	183 695	38 026
Paper and cardboard	342 579	13.6 %	311 355	30 692	532
Bio-waste	300 443	11.9 %	294 975	220	5 248
Glass	76 703	3.0 %	75 684	4	1 015
Metal	14 465	0.6 %	14 152	42	271
Wood	23 662	0.9 %	5 563	16 866	1 233
Plastic	13 227	0.5 %	11 969	1 258	0
WEEE	50 832	2.0 %	45 187	1 386	4 259
Other	179 073	7.1 %	20 378	133 227	25 468
Total	2 520 004	100 %	822 152	557 131	1 140 721

The most recovered waste materials are paper and cardboard, bio-waste, glass and metal. (Jätelaitosyhdistys 2011f). In 2008, about 6 % of municipal solid waste was composted and about 2 % was anaerobically digested for biogas production. (HE 199/2010 vp)

A key objective of municipal solid waste management is to reduce the amount of landfilled organic waste. One instrument to achieve this is energy use of MSW (figure 11). For waste incineration, different kinds of combustion techniques can be used. For sorted municipal waste fixed bed combustion is used, whereas dual combustion (e.g. fluidized bed combustion, gasification) is suitable for clean and homogenous packing and wooden waste from trade and industry. The waste incineration directive (No. 4) requires efficient purifications and controlling for the emissions. (Jätelaitosyhdistys 2012a)

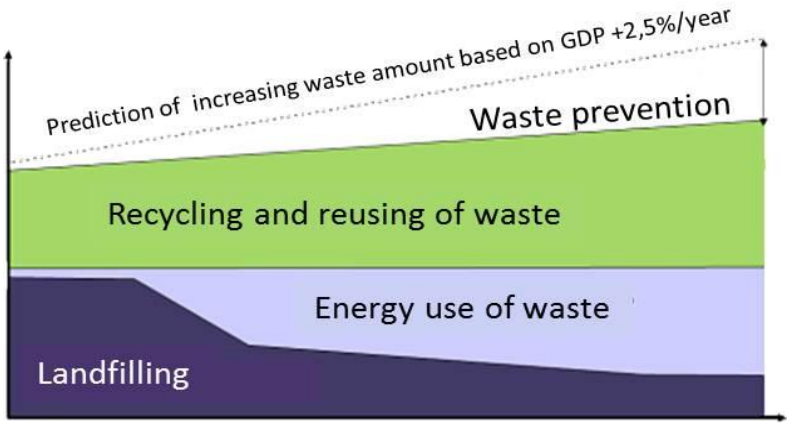

FIGURE 11 THE WASTE FOR THE ENERGY USE IS TAKEN FROM THE LANDFILLED WASTE SEGMENT JÄTELAITOSYHDISTYS (2012A)

In 2009, about 300 000 tonnes of mainly municipal waste was burned in waste incineration plants in Finland. The amount of dual fuel for conventional power plants has been 100 000-200 000 tonnes (5-7 % of municipal solid waste) per year depending on the market situation. Dual fuel is usually made from separately collected combustible waste fractions. (HE 199/2010 vp) Waste incineration plants in Finland are located in Turku, Riihimäki and Kotka. In addition, some amount of waste of good quality is burned in conventional power plants as a dual fuel. According to the current plans, there will be enough capacity for waste incineration in Finland in 2015 since the capacity of plants that are in operation, under construction or consideration will be 1,14 million tonnes of waste altogether (figure 12). About 70-80% of capacity is reserved for municipal waste and the rest of the capacity is for energy use of wastes from industry. According to the present strategies, one third of municipal waste is to be used as energy. (Jätelaitosyhdistys 2012a)

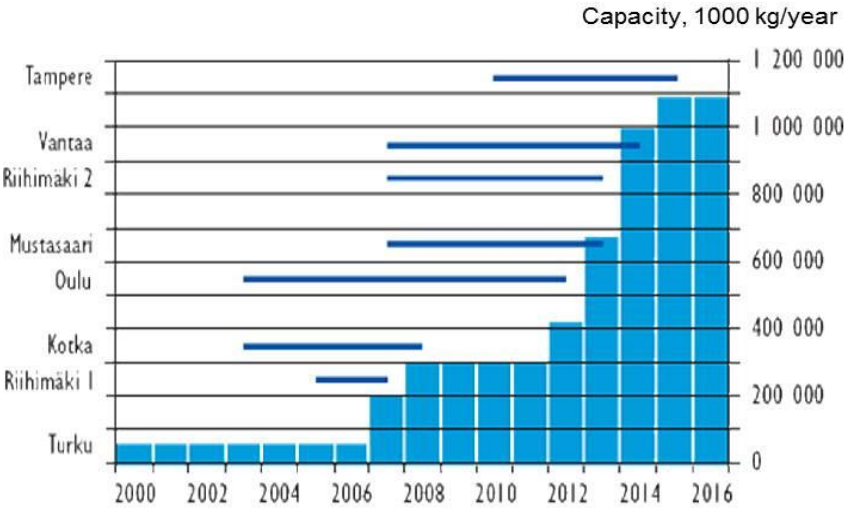

FIGURE 12 WASTE INCINERATION PLANTS THAT ARE IN OPERATION, UNDER CONSTRUCTION OR CONSIDERATION AND THE INCREASE OF WASTE INCINERATION CAPACITY. (JÄTELAITOSYHDISTYS 2012A)

There are much more restrictions in material use of waste material than in energy use. The basic requirement for the establishment of the recycling systems is the existence of a recipient facility that can utilize the recovered waste. In addition, there needs to be demand for the product made from waste. The recovered waste material is always competing with virgin raw material and is considered as substitutive material for them. The waste fraction must be suitable for the production process of the product so that the production will preferably not be more expensive than when using virgin products. Ideally, the same

process should be able to utilize virgin raw material if there is insufficient amount of waste material available. (Myllymaa et al. 2008a)

Sometimes the location of the producers of the waste and users of the waste material are not situated near each other. The transportation distances add to the costs of waste recovery. In some cases the costs of the waste recycling are so high that they outweigh the costs of the avoided material and energy expenditures. (Myllymaa et al. 2008a)

In case of waste derived fuel, called recovered fuel (REF), the average price for REF is estimated to be 0 euro/tonne. The price for REF made from waste wood is positive, whereas the producer of the REF from mixed combustible packaging waste needs to pay for the incineration. Therefore, the estimated selling price of the REF fuels is negligible (Ympäristöministeriö 2010b).

MUNICIPAL SOLID WASTE MANAGEMENT IN OULU

SEPARATE COLLECTION OF MSW IN THE CITY OF OULU

According to the waste management regulations of the City of Oulu, properties are obliged to have collection bin for mixed waste. In addition, residential building with a minimum of four apartments must have separate collection bin for waste paper, cardboard and bio-waste. In addition, residential buildings with a minimum of ten apartments need to have separate collection bins for carton and liquid packages, metal and glass. Other properties, such as office and business premises, industrial properties, schools and restaurants need to have collection bins for waste paper, bio-waste (if the property has canteen or foodstore), for cardboard (if it is produced over 10 kg/week), for paperboard (if it is produced over 10 kg/week) for glass (if it is produced over 20 kg/week), for waste wood (if it is produced over 20 kg/week), and for metal waste (if it is produced over 10 kg/week). (Oulun kaupunki 2006)

Bio-waste needs to be transported to the licensed composting plant or composting area by using organized waste transportation, or it needs to be composted in the property. All the separately collected waste fractions need to be recycled. Small residential buildings are obliged to transport their recyclables to the regional waste collection points and to compost their bio-waste if possible. Recyclables need to be collected separately in public events as well. (Oulun kaupunki 2006)

THE OULU WASTE MANAGEMENT COMPANY

The Oulu Waste Management Company (Oulun Jätehuolto) is a public-service company of the city of Oulu. It is responsible for waste treatment, coordination of waste transport and waste education and supplementary services. The waste management operations are funded by the fees collected from the delivery of waste to the Rusko Waste Management Centre and funds received from the sale of methane gas produced in waste management centre and from other services. Tax moneys are not used for the operations. (Oulu Waste Management 2012)

RUSKO WASTE MANAGEMENT CENTRE

Rusko Waste Management Centre consists of 93 hectares of protected park area of which 5.5 hectares are in use for landfilling of mixed waste and construction waste (figure 13). The remaining area is for operations such as preparing for re-use stations, hazardous waste storage, composting area and offices. About 300-350 customers visit waste centre every day. Customers can bring their reusable and recyclable domestic waste and hazardous waste to the free recycling station in Rusko Waste Management Centre. (Oulu Waste Management 2012)

1. Landfill for hazardous and special waste
2. Composting plant
3. Composting field for oily soils
4. Treatment plant for liquid waste
5. Composting field for bio-waste
6. Oil station
7. Recycling area: Oivapiste
8. Sorting area for construction waste
9. Scales and customer service premises
10. Sorting facilities for hazardous waste
11. Hall for energy waste
12. Biogas pumping station
13. Landfill
14. Infiltration basin
15. Reception for garden waste and clean timber
16. Administration

FIGURE 13 RUSKO WASTE MANAGEMENT CENTRE (OULUN JÄTEHUOLTO 2012A)

The first point in Rusko Waste Centre is the guidance point in which a customer can find parking place, area map and instruction (Oulun Jätehuolto 2012a). Waste with fee is weighed on separate scales since the customers pay according to the weight of the waste. The more harmful the waste is, the more expensive it usually is. (Oulu Waste Management 2012)

Separately collected bio-waste from Oulu and other municipalities is handled in the composting plant. The amount of bio-waste treated in Rusko is about 8000 tonnes annually. (Oulun Jätehuolto 2012a) Rusko Waste Management Centre uses three specially designed composting drums for composting of the collected bio-waste (Oulu Waste Management 2012). Every composting drum is 125 cubic metres of volume. Bio-waste is in the composting drums for one week after which it is transferred to a designated

area for maturation. The maturation process lasts 6-12 months, when the material is ready for landscaping. (Oulun Jätehuolto 2012a)

The Rusko landfill produces methane which has been recovered and utilized for over ten years. Methane is used in the Paroc factory, in the Oulu University Hospital and for own heating purposes. One third of the landfill gases is used to produce electricity and the rest two thirds produce heat. Electricity and heat are used in the Rusko Waste Management Centre area. The remaining excess electricity is sold to the national power grid. (Oulu Waste Management 2012)

There are almost 70 recycling stations in Oulu Waste Management's operation region. These stations locate in areas that all residents have adequate possibilities to use them (near the large shopping centres or schools). Recyclables produced in households (e.g. plastic, cardboard, glass, metal and paper) can be transported to these recycling stations. Hazardous waste and small amounts of waste oil from domestic and agricultural activities and electrical and electronics waste are accepted for free. If municipality does not have waste station, local businesses and contractors are responsible to receive hazardous waste matters. (Oulu Waste Management 2012)

Oivapiste is the largest recycling point for recyclables and hazardous materials in Oulu and it is located in the Rusko Waste Management Centre (figure 14). Households are allowed to bring their cardboard, paper, paperboard, plastic, metal, clean and untreated timber, less than one cubic meter of pressure treated timber, packing glass, tires (with and without rims), WEEE, hazardous waste and expanded polystyrene for free. (Oulu Waste Management 2012)

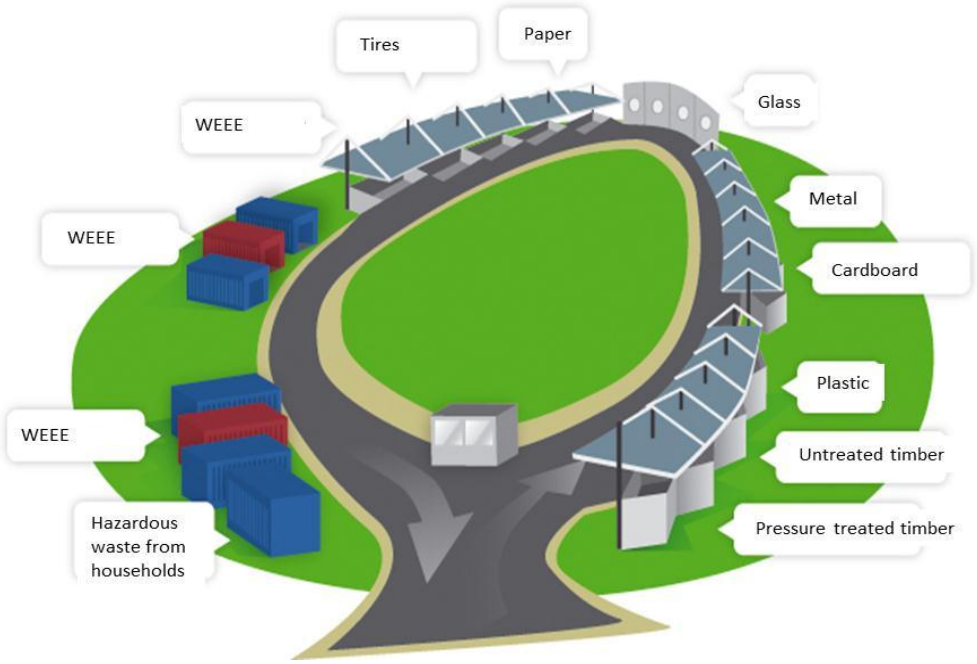

FIGURE 14 OIVAPISTE OF RUSKO WASTE MANAGEMENT CENTRE FOR THE COLLECTION OF HOUSEHOLD WASTE (OULUN JÄTEHUOLTO 2012A)

UTILIZATION OF RECOVERABLES COLLECTED IN OULU AREA

The amounts of separately collected recoverables have increased steadily during the past ten years (figure 15).

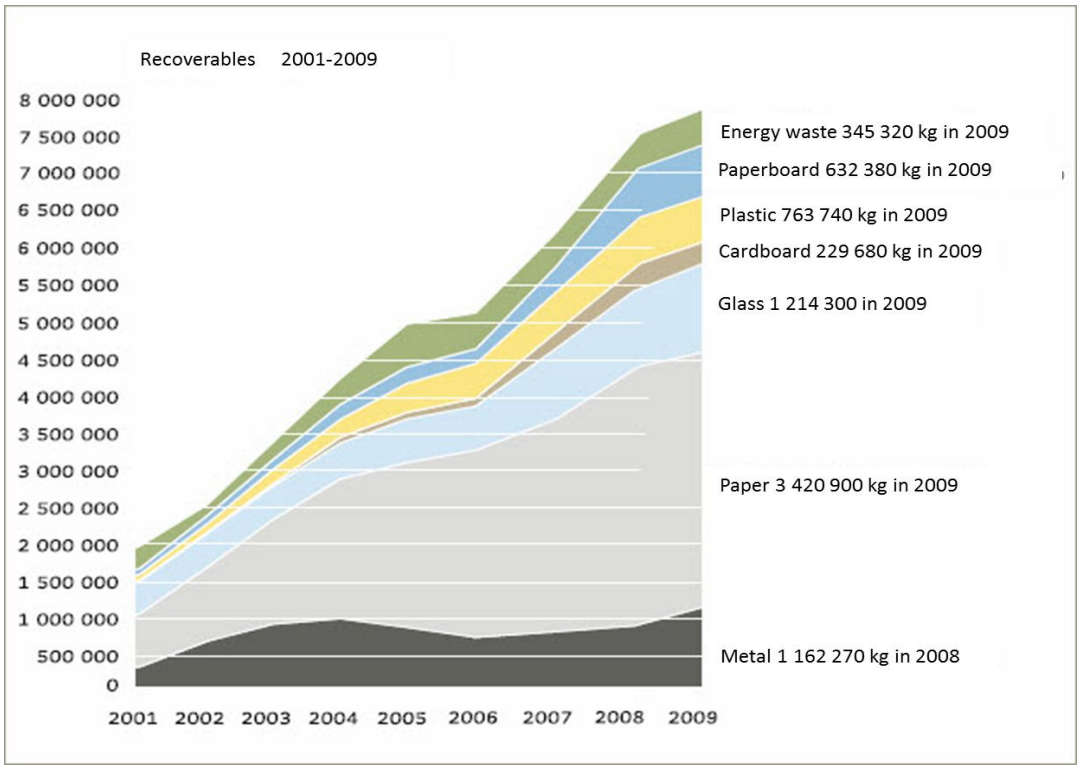

FIGURE 15 THE AMOUNT OF RECOVERABLES GENERATED IN OULU WASTE MANAGEMENT OPERATING AREA. (OULUN JÄTEHUOLTO 2012B)

The bio-waste which is composted in Rusko Waste Center is used for landscaping and construction work at the waste centre (Oulun Jätehuolto 2012a). Part of the MSW and waste from industry is used for the production of recovered fuel (REF). Most of REF was earlier used in Kajaani (heating plant of Kainuun Voima Oy) and some of it was transported to Anjalankoski, Kokkola and Pietarsaari (figure 16). In the future, combustible waste fractions will be incinerated in the Laanila incineration plant in Oulu. (Oulun Jätehuolto 2012a, Illikainen 2012) The collected waste paper is recycled to newspaper, catalogs, toilet paper and kitchen paper whereas cardboard is recycled to coreboard, packing board and corrugated cardboard. Some waste paper is used for the preparation of wood fibre wool. (Turunen et al. 2008). The collected glass is used in the earthworks of Rusko waste management centre (Illikainen 2012). In addition, some of the glass was transported to Forssa to be used as raw material e.g. for the preparation of thermal insulation material. (Turunen et al. 2008). Some of the glass is stored for later use. Metal is used as a raw material in industry (Oulun Jätehuolto 2012a), mostly in the Outokumpu factory in Tornio (Illikainen 2012). The collected cardboard in used in the factory in Pori (Suomen kuluttajakuitu ry 2011a)

FIGURE 16 TRANSPORTATION DISTANCES OF RECOVERED MATERIALS FROM OULU TO THEIR UTILIZATION FACILITIES

ECONOMIC INSTRUMENTS OF MSWM IN FINLAND

The purpose of economic instruments is to create incentives for people to change their behavior to cause less environmental pressure e.g. finding ways of preventing waste production or selecting less damaging waste management options. (European commission 2003)

It is estimated that the overall costs of waste management as a turnover of companies in waste sector in Finland were about 1750 million euros and the number of personnel 4300 in 2007. These figures don't include management of sludge and contaminated soil. The net costs of waste management to the waste producer are 1148 million euros annually (figure does not include the cost of producer responsibility system) (table 6). While the amount of MSW of total waste amounts is about three percent but the cost of municipal solid waste management (MSWM) attributes to 36 percent of total waste management costs. (Ympäristöministeriö 2010a)

TABLE 6 SUMMARY OF NET COSTS OF THE WASTE MANAGEMENT IN DIFFERENT WASTE SECTORS (INCLUDING WASTE TAXES, VAT 0%) (YMPÄRISTÖMINISTERIÖ 2010A)

Waste producer	Waste amount (million tonnes/year)	Costs (million euros/year)	Average costs (euros/tonne)
Households and public services*	2	414	205
Trade and other private services	1	65	109
Housebuilding and earthwork	23	440	19
Extractive activities	22	60	3
Industrial activities	18	92	5
Energy management	2	24	15
Water supply services	1	40	40
Agricultural industry	2	13	6
Total	71	1 148	

*Without composting in properties

The costs of MSWM have increased due to the investment in landfills, waste incineration plants and other treatment facilities. The recycling of waste material causes costs as well since the waste material need to be preprocessed for the production and usually the waste material is not very valuable. Incomes of waste management consist of reception fees of waste and selling of the material and energy. The world market price of raw materials has fluctuated strongly during the past years and this has affected the waste sector as well. There has been a demand for some waste material as the raw material prices have increased and the investments in the Far East have increased. On the other hand, the prices of the recovered materials have dropped because of the economic depression and need decreased due to reduction of new investments. Therefore, both the demand and supply and the price of waste material have fluctuated strongly. (HE 199/2010 vp)

WASTE TAXES AND CHARGES

Common economic incentives are waste charges for collection and transportation of waste, and waste taxes, charges and fees such as taxes on landfill and packaging [table 7, European Commission 2003].

TABLE 7 ECONOMIC INSTRUMENTS IN FINLAND (FINNISH ENVIRONMENT INSTITUTE 2012)

Economic instrument	Purpose	Amount of the charge
Municipal waste charge	Waste transportation Establishment, maintenance, decommissioning and after-care of treatment facilities Register maintenance and waste guidance	According to the waste tariff approved by the municipality Usually a smaller fee for waste that is sorted and fit for use compared to the mixed MSW
Waste tax	To encourage the public to reduce waste To make waste less harmful To utilize waste	40 euros/tonne from 2011 50 euros/tonne from 2013
Drinks packaging taxes	To encourage the reuse of drinks packages To reduce the landfilling of drinks packages To prevent litter	0.51 euros/litre
Oil waste charges	Managing oil wastes Cleaning up soil and groundwater contaminated with oil	5.75 euro cents/kilo

MUNICIPAL WASTE CHARGES

Municipal waste charges are collected for the establishment, maintenance, decommissioning and purification of waste treatment facilities and for the transportation of wastes. The aims of the waste charges are to reduce the quantity and risks of waste generated and to improve waste recovery. Waste holders pay waste charges and the rates are set by municipalities. The charges include transportation and waste treatment fees and many times they are lower for sorted wastes and for wastes that can be recovered in comparison with mixed wastes. The average fee was 102 euro/tonne of municipal waste and average fee for bio-waste was 68 euro/tonne in 2007. (Finnish environment institute 2012).

WASTE TAX

Waste tax act of Finland came into force in 1996. The aim of waste taxes is to improve waste recovery and to decrease the quantity of landfilled waste. Waste taxes are for wastes that are brought to public landfill sites. If wastes are recovered or suitably treated e.g. through composting or incineration, there is no need to pay waste taxes. The owner of the landfill pays the waste taxes. The original producer of the waste pays the costs by paying the fees when delivering wastes. Waste taxation has helped to reduce the quantity of waste coming in public landfills despite the increasing consumption. Waste taxes affect particularly the amount of wastes of construction, commercial and industrial activities but they are less effective in limiting household waste. The Finnish Customs authority is liable for the collecting and controlling the waste taxes. (Finnish environment institute 2012)

DRINKS PACKAGING TAX

Drinks packaging taxes are paid on packages for alcoholic beverages, soft drinks, bottled water and certain other drinks packages. The aims of these taxes are to increase the reuse and to lessen the quantities of landfilled drinks packages, and to restrain littering. This tax is not for packages in returnable deposit systems involving the collection of packages for refilling or recycling as material. Drinks packaging taxes have effectively increased the amount of returned drinks packages in Finland since in 2006 almost 98% of the refillable drinks packages were returned and 88% of the packages whose materials can be recycled. There is special legislation on the taxation of the manufacture of certain types of drinks packaging (1037/2004), as well as statutes in the Waste Act and a related decree on collection systems for returnable drinks packages (180/2005) in Finland considering the returnable deposit system. (Finnish environment institute 2012).

OIL WASTE CHARGES

The oil waste charges are added to the prices of lubrication oils. These charges are used for the costs of managing oil wastes and cleaning up soils and groundwater which are contaminated with oil. (Finnish environment institute 2012).

COSTS OF MSWM IN HOUSEHOLDS AND PUBLIC SERVICES

In the report of the Ministry of Environment (Ympäristöministeriö 2010a) the economic impact of waste management was estimated based on statistics and surveys. The collection of MSW is organized either by using property specific or regional waste collection.

PROPERTY SPECIFIC WASTE COLLECTION

Municipals collect the waste in different ways: as separate section, as mixed waste, or by a "two bags system" (bio-waste in black bag and energy waste in white bag) (table 8). Bio-waste is usually collected by using 240 l containers (95 % of bio-waste) or much larger containers (volume of 3 m^3). Paperboard and cardboard is collected only from the largest properties. As paper waste falls under Extended Producer Responsibility systems, properties need to pay only for the purchase and maintenance of bins. (Ympäristöministeriö 2010a)

TABLE 8 ESTIMATE OF ANNUAL WASTE AMOUNTS COLLECTED FROM PROPERTIES (PRODUCED IN HOUSEHOLDS AND PUBLIC SERVICES). (YMPÄRISTÖMINISTERIÖ 2010A)

Waste section	Households and public services (tonnes/a)
Mixed waste	1 185 000
Energy waste	40 000
Bio-waste	156 000
Paper	210 000
Paperboard and cardboard	20 000
Total	1 611 000

The costs of maintaining the waste containers consist of the purchasing, wearing, washing and fixing of the containers. Usually properties purchase containers that are large enough to be emptied only once a week. In single-family houses containers can be emptied every fourth week. Smaller containers are emptied every second week whereas large containers are emptied every 1,5 weeks. The rental price of the 240 liter container is 10-50 euros and of the 600 liter container 14-50 euros. It is estimated that there will be 48 emptying times per every tonnes of mixed waste annually. The cost of the emptying of the waste container consists of the costs of transportation and treating of the waste, and VAT. In addition, there is a waste tax for the waste that is landfilled. If there is no possibility to weigh the amount of the waste, the cost is based on the estimate. Usually the households pay according to the number of emptying of the waste container. The weight of the waste is possible for example the waste is collected to the interchangeable container. (Ympäristöministeriö 2010a)

The collection price of the specific waste sector does not need to be the same that the managing the waste section itself since the idea of the waste law is to direct the waste production according to the waste hierarchy. The handling of the bio-waste and energy waste is subsidized by collection fee from mixed waste. The costs of waste management organized by municipalities are collected fully from the producers of the waste and possible profits are used for the developing the existing system. The profits collected from the sales of the recoverables and excess energy are taken into the account when deciding on waste fees. The emptying fees vary a lot depending on the transportation system, competitive bidding and since

they may include different kinds of services (washing of the container, rent). In addition, treatment fee may include costs of organizing the treatment of hazardous waste and recoverables and consultation. (Ympäristöministeriö 2010a)

According to the studies of Consumer Agency (Kuluttajavirasto 2010), the emptying of mixed waste container of single-family house costs from 3,78 euros to 11,95 euros average being 6,45 euros. Especially high price spread was in price of emptying of bio-waste containers. Only half of the municipalities have organized the bio-waste collection. The price for the emptying of bio-waste container of single family house costs 7,10 euros in average (varying from 3,17 to 16,71 euros) and in some companies the bio-waste bag is included in price but not always. Only one fifth of municipalities have organized the collection of energy waste from single-family houses. The emptying price was 5,53 euros varying from 3,5 euros to 8,54 euros. (Kuluttajavirasto 2010)

The Association of Environmental Enterprises (YYL 2010) claims that there are no significant differences between contractual and competitive bids in waste transportation in the prices of emptying of waste containers. The price of emptying in contractual waste transportation was 6,11 euros and in competitive bid waste transportation organized by municipalities it was 6,67 euros. (YYL 2010). According to Finnish Solid Waste Association the price for emptying of the mixed waste container is always lower when the transportation is organized by municipalities using competitive bidding compared to contractual waste transportations Association of Environmental Enterprises (2009) has therefore studied the total annual cost of waste management services in single family houses. The average price of waste management for 377 single family houses was 177,46 euros in contractual waste transportation system and 170,58 euros (inc. VAT) in when the transportation was organized by municipalities using competitive bidding (352 houses). Association of Environmental Enterprises (2009) claims that the differences in prices are caused by the higher waste treatment fee for contractual waste transportation system. In addition it is said that the contractual waste transportation system is more flexible when households want for example extra emptying of waste containers. (YYL 2010)

The total amount of the emptying fees of mixed waste from households and public sector are about 280 million euros in Finland annually (table 9). The total cost of mixed waste management of households and public sector is about 340 million euros annually. (Ympäristöministeriö 2010a)

TABLE 9 THE COSTS OF MIXED WASTE MANAGEMENT (YMPÄRISTÖMINISTERIÖ 2010A)

Cost factor	Cost (euros/year)
Transportation	146 131 000
Treating	136 326 000
Maintaining the containers	56 435 000
Total	338 892 000

REGIONAL COLLECTION

Regional collection is organized for waste fractions that are not produced in large enough amounts in properties or are not suitable for normal waste transportation. In some municipalities also the mixed waste may be collected to the regional collection points if the area is sparsely populated. Properties use common waste bin which is sustained and emptied by municipalities. Properties pay regional collection fee for this service. (Ympäristöministeriö 2010a)

The costs of MSWM of wastes from households and public services to service providers are estimated to be 211 million euros/year (41 euros per inhabitant/year). Total costs of the waste management of household and public service waste are about 414 million euros yearly (table 10). (Ympäristöministeriö 2010a)

TABLE 10 SUMMARY OF THE COSTS OF THE WASTE MANAGEMENT OF THE WASTE FROM HOUSEHOLDS AND PUBLIC SECTOR IN FINLAND (INCL.WASTE TAX, VAT 0%). (YMPÄRISTÖMINISTERIÖ 2010A, 41)

Cost factor	Transportation and handling (euro/year)	Collection containers	Total (euro/year)
Mixed waste	282 457 000	56 435 000	338 892 000
Ekofee	15 876 000		15 876 000
Energy waste	16 013 000	3 032 000	19 045 000
Separeately collected bio-waste	23 804 000	3 140 000	26 944 000
Waste paperboard	8 867 000	960 000	9 827 000
Waste paper	0	1 590 000	1 590 000
Sludge form septic tank and cesspit	2 190 000	0	2 190 000
Total	349 207 000	65 157 000	414 364 000

In conclusion, the average cost of waste management per tonne of waste is about 205 euros if cost of containers is included. The costs without containers are 173 euros per tonne. The cost of waste management of solid waste is about 57 euros per inhabitant (excluding the costs of containers) and 67 euros with containers. (Ympäristöministeriö 2010a)

COSTS OF PRODUCER RESPONSIBILITY SYSTEMS

The costs of producer responsibility systems are covered with utilization fees that are collected from the producers (table 11). The utilization fees for packaging materials is 0,4 - 35 euros depending on the material. (Suomen Kuitukierrätys Oy 2012)

TABLE 11 UTILIZATION FEES FOR PACKAGING (SUOMEN KUITUKIERRÄTYS OY 2012)

Material	euro/tonnes + VAT
Corrugated board	3,5
Industrial covers and sacks	18,0
Cores	18,0
Cardboard packages and paper covers	25,5
Liquid cardboard packages	35,0
Plastic packages	21,0
Plastic packages as a part of recyclable bottle system	-
Aluminum packages	24,0
Sheet tin packages	24,0
Steel packages	5,0
Metal cans with reward	-
Glass bottles with reward	-
Wooden packages	0,4
Others	-

Several organizations are collecting WEEE in Finland (appendix 4). It is estimated that the management of WEEE cost about 14 million euros annually. Presently, producers are collecting only about half of all the WEEE, and primarily organize the collection and treatment of the most valuable WEEE. The costs of tire recycling is about 7-8 million euros which includes almost all the waste tires. Management of scrap cars does not entail excess costs, since the value of metal from the vehicles covers the waste management expenditures. The producers of all the packaging types (glass, metal, fibres, plastic, wood) have collected about 1,5 million euros for the information system and organization annually and, in addition to that, 3,4 million euros of utilization fees. The data about the costs of producer responsibility system for paper was not available. (Ympäristöministeriö 2010a)

COSTS OF NEW COLLECTION NETWORK FOR PACKAGING MATERIAL

As there will be changes in managing of packaging material because of the new waste law (the partial producer responsibility for packaging is turning to full producer responsibility), the Ministry of Environment (Ympäristöministeriö 2010b) estimated the costs of the requirements of the new collection network. There should be reasonable possibilities for all the inhabitants to be able to utilize the regional collection points of packaging material. There were three different models: standard network (1 372 collection points), sparse network (1 014 collection points) or dense network (2 550 collection points).

In the models the collection points need to be emptied so often that there will not be littering or putting the recoverables to the mixed waste containers (emptying every 1-16 weeks depending on the waste sector). For the new collection point, the costs are composed for example of the establishment costs (land, licenses, building, containers), annual costs (investment costs, emptying, maintaining) and administrative and consulting costs. The number of inhabitants in the area effects on the amount of the material collected, emptying times and methods. It is estimated that the collection point of four waste sectors needs the land area of 62 m^2. The container for paperboard needs 41 % of that area, plastic 23 %, glass 18 % and metal 18 % (figure 17). (Ympäristöministeriö 2010b)

The price of the containers depends on the model of the container (surface or deep collection). In addition, it is estimated that the information board and licenses for one collection point cost about 100 euros and the maintaining and administrative costs are about 90 euros/material/collection point/year. The purchase price for the waste containers depends on the number and size of the container. (Ympäristöministeriö 2010b)

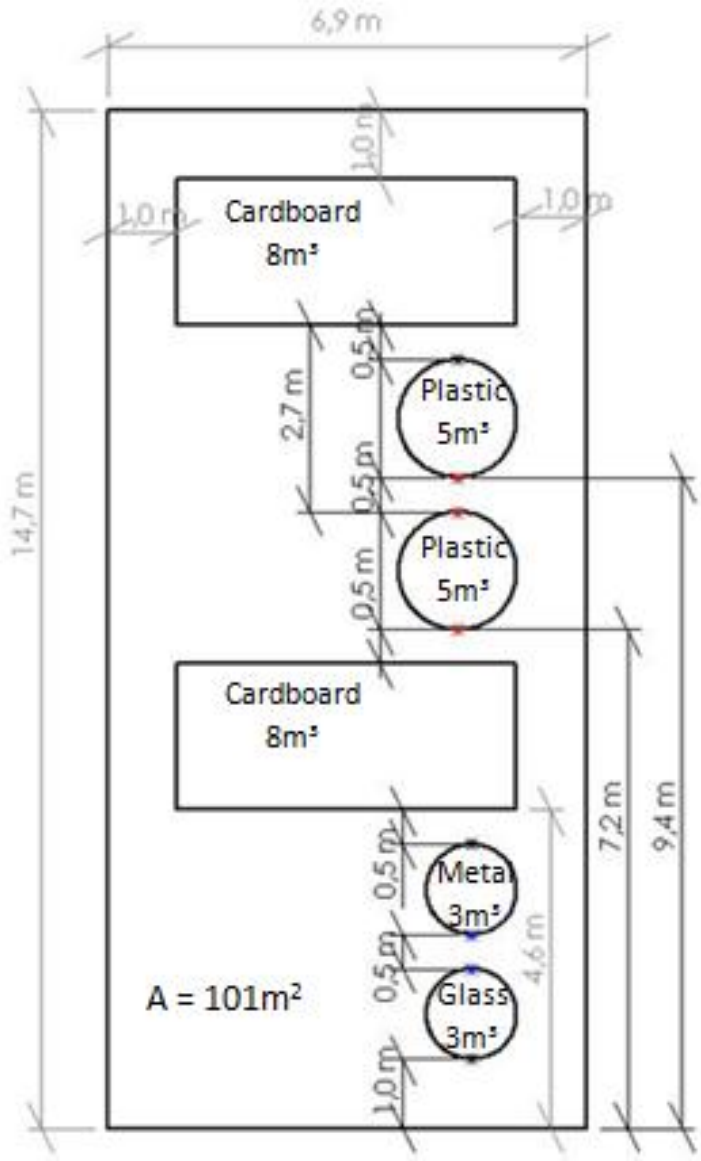

FIGURE 17 LAYOUT OF THE REGIONAL COLLECTION POINT (YMPÄRISTÖMINISTERIÖ 2010B)

Usually the land area is rented. In addition, there will be costs caused by the wearing of the land and containers. The emptying costs of the containers depend on the size, type and location of the container and they varies very strongly (from 10 euros to even 160 euros per emptying). The prizes for the emptying are then estimates. Collected material can be transported to the pretreatment facilities or directly to the utilization plant. Depending on the collection area, some recoverables are used as material or energy. The number of the collection points differs depending on if the collection network in standard, dense or sparse and the numbers of the containers differs depending on the material collected and the number of the inhabitants in the collection area. The total cost of the collection points depends on the type of the network and the type of the collected material. The estimate of the costs of the establishment of the one collection point for four waste material is about 11 700 – 13 700 euros. The high establishment cost of the collection point for sparse network is due to the centering of the collection on the large service area. The annual costs vary depending on the network and waste type varying from 520 euros to 3 680 euros per waste fraction. Annual costs of collection point for four waste sector is 5 300-6 300 euros per year. (Ympäristöministeriö 2010b)

TOTAL COSTS OF WASTE RECOVERY IN FINLAND

It is challenging to estimate the total environmental and economic cost of waste recovery since there are many issues affecting on the costs. Myllymaa et al. (2008a, b) have made some calculations of those costs for some combustible waste fractions in different kind of areas (infrastructure, location, residential density, waste amounts and fractions, industry in the specific area, etc.). In addition, the report takes into account if the recoverables are used for material or for energy, what are the transportation distances, what materials they are replacing and so on (Myllymaa et al. 2008b)

The transportation costs for one tonne of every waste fractions and different transportation distances were calculated based on the weight of the waste load, the travelling distance and the hourly cost of the used vehicle (83 euros). The consumption of diesel was based on the figures from Mäkelä (2002). It was estimated that the speed of the vehicle was about 50 km/h when driving short distances (less that 10 km) and 70 km/h in longer distances (over 10 km). The time for the loading and unloading of one load was estimated to be 30 minutes for loads under 15 tonnes and about one hour if the load was heavier. Also the breaks and refilling was taken into account by using the coefficient 1,15. It was estimated that the weight of one load was 7,4 tonnes for mixed waste, 9,4 tonnes for bio-waste and 24 tonnes for REF (Isoaho 2008 in Myllymaa et al. 2008b). The average costs of collection of mixed waste and bio-waste is assumed to be 60 euro/tonne (Motiva 2007; Nummela 2007 in Myllymaa et al. 2008b)

The establishment price or the small (6 000t/year) barrel composting plant is about 2 million euros and the annual treating cost is almost 100 euro per treated bio-waste tonne (Illikainen 2007 in Myllymaa et al. 2008b). The production of peat mold from the compost pays about 10 euros per output tonne. (Laine 2007 in Myllymaa et al. 2008b) The investment costs of the small-scale anaerobic digester (6 000 tonnes of bio-waste and sludge from waste water treatment) are much lower (about 670 000 euros) and the annual treating costs of bio-waste are just 15 euros/tonne. In addition, it is possible to produce electricity by using anaerobic digester. (Luostarinen 2008 in Myllymaa et al. 2008b) Processing costs in this case are lower than in composting since composting plants use quite sophisticated technique which increases the costs of composting. It needs to be noticed that the main aim of collection and composting of the bio-waste is to produce inexpensive material to replace the peat but for the need of the waste management system. (Myllymaa et al. 2008a) The total annual costs for the landfill depend strongly on the size and the operation time of the landfill. The total annual costs for the landfill with capacity of 450 000 tonnes of waste and operating time 8-10 years are about 29 euros per tonne (Vänskä 2007 in Myllymaa et al. 2008b)

PRICES OF RECOVERABLES ON THE EUROPEAN MARKET

The price of recycled materials is highly dependent on the price of raw materials and, therefore, by the overall economic devepment. The prices of recoverables may vary strongly during the years (figure 18). The average price for tonne of recycled steel was already 340 euro/tonne in Germany in March 2012. (Teknologiateollisuus ry 2012) The price for recycled non-ferrous metals is not known but it usually is multiple compared to the price of scrap steel (Ympäristöministeriö 2010a).

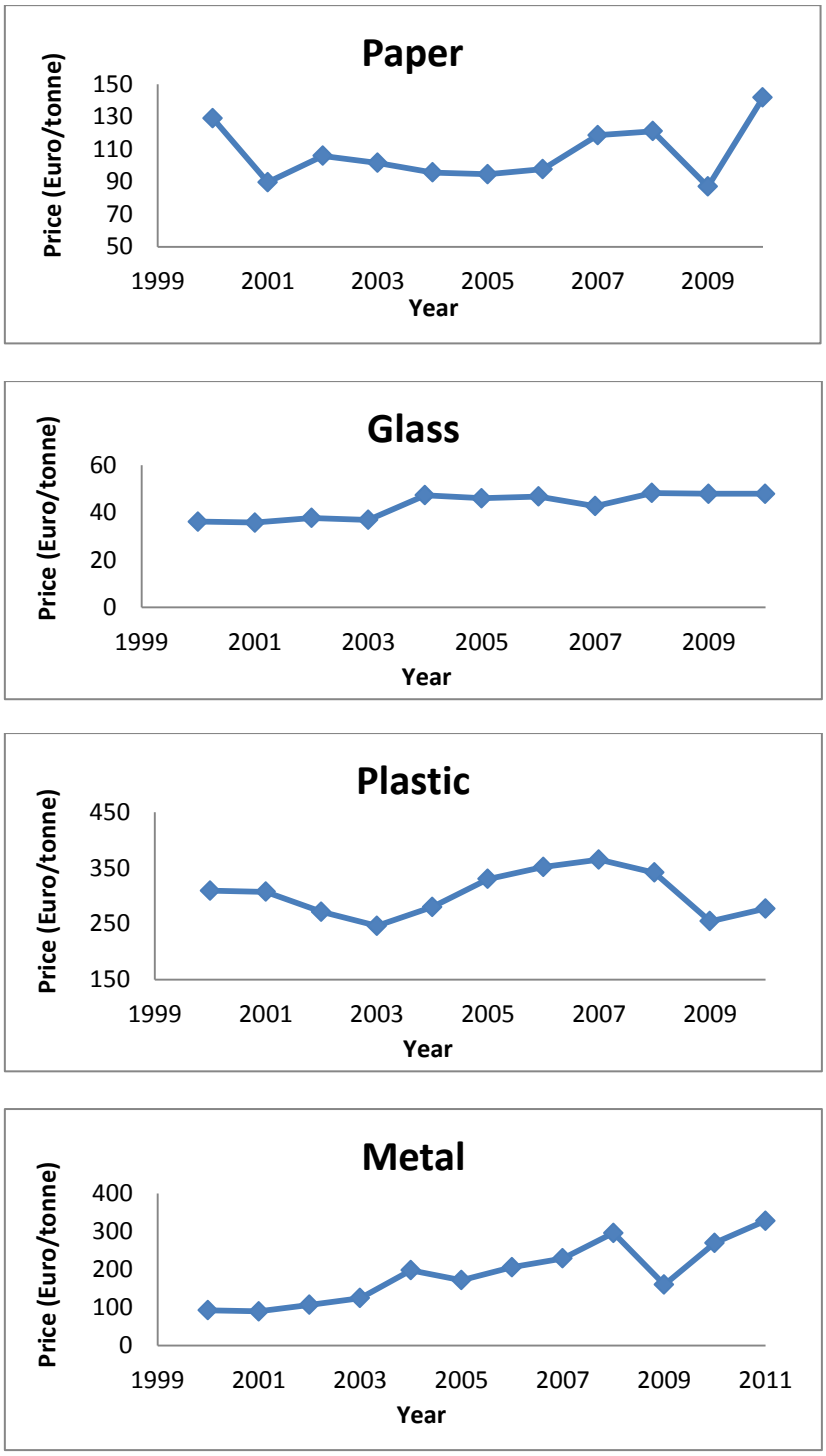

FIGURE 18 AVERAGE PRICES OF RECOVERABLES (EURO/TONNE) IN EUROPE IN 2000-2011 (EUROSTAT 2012; TEKNOLOGIATEOLLISUUS RY 2012)

The price for recycled paper depends on the type and quality of the paper. If the paper is well sorted, clean and consist of large amounts of bleached chemical pulp, the price is higher than average. The price of the waste paper fluctuates strongly depending on the current market situation. As the prices may vary strongly very rapidly, it is extremely difficult to calculate the cost-effectiveness of the investments to using of the recoverables. (Laukala 2011)

CONCLUSION

Decades ago the waste management was quite cheap for municipalities since the only cost was the maintenance of the "dumping place" (Tommila 1984). Nowadays it is very well known that uncontrolled waste dumping pollutes the environment and may cause health problems (Finnish environment institute 2011a). As the amounts of virgin raw materials are limited, the recovery of waste as material or energy is very logical. Due to policy instruments, the infrastructure of waste management and the recovery of wastes have improved in Finland in the 1990s. (Melanen et al. 2002).

The recovery of municipal waste is, in general, well-organized in Finland. Most of the nutrients embedded in MSW are in the organic waste fraction and they are in a form that is easy to utilize but which is also the most liable to leaching or volatilization. (Sokka et al. 2004) Therefore, policies are increasingly addressing the organic waste component of MSW. There is a need to decrease the amount of bio-waste going to landfills and, therefore, the biological treatment and energy use of bio-waste will increase. (Jätelaitosyhdistys 2011 b)

According to the National Waste Plan (Ympäristöministeriö 2008), the primary aim is firstly to stabilize the amount of waste and then reduce the amount of the waste by the year 2016. Moreover, 50 % of MSW is to be recovered as material and 30 % as energy and only 20% will be taken to landfills. (Sokka et al. 2007)

Although the MSWM system is considered to be at the good level in Finland, the situation in sparsely populated Northern areas is still challenging. As the waste taxes are getting higher in future, landfilling may become an unfavourable option compared to energy recovery. (Lapin ELY 2011) Oulu has very well-established and well-functioning MSWM infrastructure with high reliance on kerbside recovery of recyclables. Oulu is also a hub for the collection of recyclables, some of which are transported over rather long distances for recycling. It is yet to be seen how the situation will change should the combustible fractions be routed for energy recovery.

A general tendency for the whole country is the further reduction of the number of landfills in operation. As well, waste management operators are increasingly interested in moving toward waste incineration. As only large-scale waste incineration plants are feasible, these developments will increase transportation distances. Notwithstanding, the tendency is likely to be the further centralization of waste treatment stations and will increase the need to establish new transfer stations. It is to be hoped that, in the case of bio-waste local utilization possibilities will be explored, such as co-digestion with wastewater sludge and biodegradable industrial wastes.

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Appendix 1. National statistics on quantities of packaging used in 2009 (The Environmental Register of Packaging PYR Ltd 2011d)

TABLE 12 QUANTITY OF PACKAGING PLACED ON THE MARKET IN FINLAND AND PACKAGING WASTE RECOVERY (IN TONNES)

Material	Packaging quantity placed on the market, equals packaging waste	Recovered by recycling as material	Total recovery
Glass	58 275	26 269	26 269
Plastics	112 341	28 478	50 848
Paper, board and corrugated board	241 978	229 208	272 509
Metals	46 251	38 983	38 983
Wood	194 307	39 873	186 690
Others	644		
Total	653 796	362 811	575 300

TABLE 13 REUSABLE PACKAGING AND TOTAL USE OF PACKAGING IN FINLAND

Material	Total use (in tonnes)	Reuse (in tonnes)	Quantity placed on the market (in tonnes)	Reuse rate (%)
Glass	152 917	94 642	58 275	62
Plastics	348 793	236 452	112 341	68
Paper, board and corrugated board	256 106	14 128	241 978	6
Metals	515 889	469 638	46 251	91
Wood	810 916	616 609	194 307	76
Others	1 837	1 193	644	65
Total	2 086 459	1 432 662	653 796	69

TABLE 14 THE REUSE OF A PACKAGING IS ITS USE IN THE SAME FORM AFTER CLEANING. FINLAND IS ONE OF THE TOP REUSERS OF PACKAGING IN EUROPE. (HTTP://WWW.PYR.FI/ENG/STATISTICS/REUSE.HTML)

Year	Total	Fibre	Glass	Metal	Plastic	Wood
1998	66 %	4 %	84 %	90 %	70 %	
1999	64 %	4 %	83 %	90 %	69 %	
2000	63 %	3 %	81 %	89 %	67 %	
2001	62 %	3 %	81 %	88 %	69 %	
2002	66 %	3 %	80 %	91 %	71 %	
2003	71 %	3 %	80 %	90 %	71 %	81 %
2004	71 %	3 %	78 %	90 %	73 %	78 %
2005	71 %	3 %	74 %	90 %	72 %	78 %
2006	74 %	3 %	77 %	93 %	74 %	79 %
2007	73 %	3 %	76 %	93 %	74 %	78 %
2008	71 %	4 %	65 %	93 %	69 %	76 %
2009	69 %	6 %	62 %	91 %	68 %	76 %

TABLE 15 RECYCLING MEANS THE CONVERSION OF COLLECTED PACKAGING MATERIAL SO THAT IT CAN BE USED TO MANUFACTURE A NEW PRODUCT. (HTTP://WWW.PYR.FI/ENG/STATISTICS/RECYCLING.HTML)

Year	Total	Fibre	Glass	Metal	Plastic	Wood
1998	45 %	57 %	62 %	16 %	10 %	
1999	50 %	61 %	78 %	19 %	13 %	
2000	50 %	62 %	64 %	25 %	14 %	
2001	47 %	58 %	50 %	39 %	15 %	
2002	49 %	61 %	50 %	46 %	15 %	
2003	41 %	63 %	61 %	50 %	14 %	7 %
2004	40 %	70 %	55 % *)	55 %	15 %	7 %
2005	43 %	79 %	63 % *)	54 %	14 %	5 %
2006	49 %	86 %	74 % *)	59 %	16 %	8 %
2007	52 %	88 %	81 % *)	70 %	18 %	10 %
2008	56 %	93 %	80 % *)	75 %	23 %	20 %
2009	56 %	95 %	45 % *)	84 %	25 %	21 %

*) The difference between the recycling rate and recovery rate of glass packaging is due to a decision by the authorities stating that the use of glass packaging waste as material in construction work is counted as recovery but not as recycling.

TABLE 16 THE RECOVERY OF PACKAGING WASTE CONSTITUTES BOTH THE RECOVERY OF PACKAGING TO MAKE RAW MATERIAL FOR NEW PRODUCTS AND RECOVERY AS ENERGY. THE RECOVERY OF PACKAGING IS NOT THE DELIVERY OF PACKAGING TO WASTE COLLECTION OR SORTING SITES. MERE SORTING DOES NOT CONSTITUTE RECOVERY; IT IS ONLY THE FIRST STEP TOWARDS RECOVERY. (HTTP://WWW.PYR.FI/ENG/STATISTICS/RECOVERY.HTML)

Year	Total	Fibre	Glass	Metal	Plastic	Wood
1998	56 %	72 %	62 %	16 %	20 %	
1999	60 %	72 %	78 %	19 %	30 %	
2000	60 %	72 %	64 %	25 %	36 %	
2001	62 %	74 %	50 %	39 %	44 %	
2002	61 %	75 %	50 %	46 %	38 %	
2003	67 %	72 %	61 %	50 %	37 %	84 %
2004	68 %	77 %	58 % *)	55 %	34 %	78 %
2005	68 %	88 %	65 % *)	54 %	15 %	76 %
2006	77 %	96 %	77 % *)	59 %	29 %	81 %
2007	84 %	95 %	88 % *)	70 %	43 %	90 %
2008	90 %	106 % **)	81 % *)	75 %	49 %	99 %
2009	88 %	113 % **)	45 % *)	84 %	45 %	96 %

*) The difference between the recovery rate and recycling rate of glass packaging is due to a decision by the authorities stating that the use of glass packaging waste as material in construction work is counted as recovery but not as recycling.

**) Into recovery and recycling enter also fibre packaging outside the recovery system e.g. packaging from companies with an annual turnover of less than 1 M€, internet sales and free-riders.

The recovery of plastics for 2005 only includes recycling as material.

32 234 tonnes of glass was stored up for recycling in 2009.

Appendix. 2. Waste legislation in Finland

General waste legislation

- Waste Act (646/2011)
- Waste Decree (17972012)

End-of-waste

- Council Regulation (EU) No 333/2011 establishing criteria determining when certain types of scrap metal cease to be waste under Directive 2008/98/EC of the European Parliament and of the Council (333/2011)

Waste treatment and recovery

- Government Decree on waste incineration (362/2003)
- Government Decision on landfill sites (861/1997)

Legislation on specific waste types, products and activities

- Government Decree on end-of-life vehicles (581/2004)
- Government Decree on subsidies for the processing of end-of-life vehicles (582/2004)
- Government Decree controlling the use of certain hazardous substances in vehicles (572/2003)
- Government Decree on Waste Electrical and Electronic Equipment (852/2004)
- Government Decree controlling the use of certain hazardous substances in electrical and electronic equipment (853/2004)
- Government Decision on restricting the use of PCBs and PCTs (1071/1989)
- Government Decision on the prohibition of PCBs and equipment containing PCBs, and the processing of wastes containing PCBs (711/1998)
- Government Decision on ozone-depleting substances (262/1998)
- Council of State Decision on batteries and accumulators containing certain dangerous substances (105/1995)
- Government Decision on amalgam-containing wastewater and waste resulting from dental care (112/1997)
- Government Decision on the management of oily wastes (101/1997)
- Government Decision on the use of sewage sludge in agriculture (282/1994)
- Government Decision on the recovery and disposal of discarded tyres (1246/1995)
- Government Decision on construction waste (295/1997)
- Government Decision on the collection and recovery of waste paper (883/1998)
- Government Decision on packaging and packaging waste (962/1997)
- Ministry of the Environment Decision on derogations from limitations of heavy metal concentration levels in packaging (273/2000). In force 1.4.2000-10.2.2009.

Waste shipments

- Regulation (EC) No 1013/2006 of the European Parliament and of the Council on shipments of waste (EUR-Lex)
- Government Decision on the part of the National Waste Plan concerning transfrontier waste shipments (495/1998)

Other legislation

- Waste Oil Charge Act (894/1986)

Appendix 3. Producer responsibility organization system in Finland

Pakkausalan Ympäristörekisteri PYR Oy

Pakkausalan Ympäristörekisteri PYR Oy (The Environmental Register of Packaging PYR Ltd) is a non-profit firm which co-operates with producer organizations in the packaging sector. It helps companies and the authorities to fill packaging recovery obligations since firms that place packed products on the market and have a sales volume of one million euro or more have a packaging recovery obligation/producer responsibility in Finland. If a firm has a contract with PYR, it transfers the recovery obligation to the producer organizations. (The environmental register of packaging 2011b).

Producer responsibility organization for glass packaging

Suomen Keräyslasiyhdistys was established in 1998. It is producers' organization which promotes recycling and reusing of glass, and it aims to reduce production of waste glass by sharing information about recycling and reusing of glass and by collecting the utilization fee for glass packages. Organization makes statements and tries to find out new ways to recycle glass and gives municipals reward for collected packing glass. The members of the organization are trade and importers, industry and companies using glass packaging (Suomen keräyslasiyhdistys 2011c).

Glass is collected using two different collection routes. Most of the glass is collected by using refund system which is organized by industry and trade and producer organization is decision-making body. Smaller part of glass ware is collected by the using municipal collection points. (Suomen keräyslasiyhdistys 2011h) Refundable glass packages can be returned to stores. Grocery shops are receiving beverage packagings they have sold and Alko accepts bottles for alcoholic beverages and soft drinks they have sold. Non-refundable packages can be returned to the nearest collection point. Refunded glass should be reasonable clean and sorted according to colour, if possible. (Suomen keräyslasiyhdistys 2011d). The number of collection points for refundable packages was estimated to be 8000 in 2002 (Suomen keräyslasiyhdistys 2011e).

To collection points can be returned all the clean waste glass: glass packaging (bottles and jars) and glassware. Glass material can be recycled basically forever since its quality won't suffer from reusing. Refillable bottles can be filled dozens of times (depending on the type of a bottle) until it is put out of circulation. After that, the glass can be used as a material for manufacturing new packages or glass wool. (Suomen keräyslasiyhdistys 2011f)

Refillable bottles are taken to breweries and alcoholic beverage plants for sorting, washing and refilling. Other glassware and disposable bottles with a deposit will be crashed and sorted according to their colour, after which they are used for the manufacturing of packing glass and glass wool. Part of glass from municipal collection points are crashed and sorted but some of them are landfilled. (Suomen keräyslasiyhdistys 2011g). The major suppliers of the packaging glass are Alko, beverage wholesalers and waste management companies. Delivers of float glass (e.g. windows and windscreens) are glass sellers, cutters, downstream operators and construction companies. (Uusioaines Oy 2011b)

The law in Finland permits to use recycled cullet for producing new packing glass and glass wool. Recycled cullet has been used for the manufacturing of the glass wool since 1983. The proportion of waste glass in glass wool product is about 60-80% and the share of waste glass in new packing glass is about 20%. Recycled cullet can be used for other purposes as well, e.g. for the manufacturing of glass block and glass-concrete; in swimming pool filters; for land reclamation, sandblasting and road bed. In

Finland the use for material in the road bed could be one good option since cullet has good frost resistance. In addition, there is need to discover new ways to utilize cullet because of the demand for higher utilization rate due to packing directive in future. (Suomen keräyslasiyhdistys 2011g)

Producer responsibility organization for fibre packaging

The earlier producer organizations for fibre packaging, Suomen Kuluttajakuitu ry (consumer fibres), Suomen NP-kierrätys Oy (carton liquid packaging) and Suomen Aaltopahviyhdistys ry (corrugated board), have closed down their operations as producer organisations. Together they have established Suomen Kuitukierrätys Oy but will go on with their activities in packaging recovery. (The Environmental Register of Packaging 2011e) Suomen Kuitukierrätys Oy producer is organization for fibre packages like paper, cardboard and corrugated cardboard packages. (Suomen kuitukierrätys Oy 2011)

Fibre packages are environmentally friendly since they can be reused again. Usually these packages are packages used for customer products like cardboard boxes, paper bags, egg cases and disposable containers. Recyclable packages for liquid foodstuff belong to this group, e.g. milk and juice cartons, also aluminum coated. Corrugated cardboard is the most common material in the transport packings such as boxes and wrappings. Fibre packages are collected from properties and there are 1800-1900 collection points in densely populated area. Shops and industry produce corrugated cardboard and industrial fibres. Fibre packages are reused as material for corrugated cardboard and cardboard but there is still need to develop applications that can replace the use of virgin wood or pulp. (Suomen kuitukierrätys Oy 2011)

All the carton liquid packagings are recyclable, even with aluminum coating and plastic parts (e.g. cap). Packages need to be washed and flattened and taken to the collection point. (NP-kierrätys 2011a) Empty carton liquid packagings are sorted, baled and transported to cardboard factory as raw material. Fibre is then separated from plastic and reused as material for coreboard. (NP-kierrätys 2011b) Separated plastic is burned as energy and aluminum is recycled. (Suomen kuluttajakuitu ry 2011a). There is no need for deinking of the used packages. Recycled cardboard is used in the factory of Corenso United Ltd in Pori and Fiskeby cardboard factory in Sweden. (Suomen kuluttajakuitu ry 2011b).

Producer responsibility organization for beverage containers

Suomen Palautuspakkaus Oy (PALPA) is owned by the retail trade and the breweries and it administers and develops deposit-based systems for beverage containers in Finland. The return percentage goal level is 90 %. The recycling system of beverage containers is very comprehensive in Finland since almost all soft drink, water, beer, cider, long drink and sport drink bottles and cans have a deposit. Since 2008 recyclable plastic bottles (spring water, mead, iced tea and wine) have had a deposit. (Palpa 2011c)

PALPA administers the recycling of beverage containers. A very large proportion of the beverage containers is recycled or reused because of the system of deposits paid on returned containers. (Palpa 2011d) The returning percentage of used bottles is very high, since 97% of the bottles are recycled. Glass bottles are used 33 times on average. Cast-off glass bottles are used for new glass ware or glass wool and labels are used as energy. (Palpa 2011e)

Nowadays the returning rate of beverage cans is about 90 %, which is top class worldwide. Returned aluminum cans are melted and used as material for new beverage cans and recyclable plastic bottles are not reused as bottles but the plastic is recycled. (Palpa 2011b) Empty plastic bottles from the shops are transported to the recycling center, after which they are baled, crushed, washed, granulated for utilization as raw material e.g. for new bottles. (Palpa 2011f)

Producer responsibility organization for plastics

Suomen Uusiomuovi Oy (The Finnish Plastics Recycling Ltd) is a producer organization for plastic. It was founded in order to improve the recycling of used plastic products in Finland. Most of the plastics are produced from the byproducts of oil refining. The recycling of used plastic has been executed almost from the beginning of the use of plastic but it has become business only with more common use of plastics and because of the more efficient use of raw materials. The recycled plastic needs to be well sorted and clean. There are several ways for the utilization of used plastic products: they can be used again as a product (cages, boxes) or as material (refuse sack, plastic pipe) as there are several plants in Finland that are recycling plastic. In addition, plastic can be used as energy in appropriate power plants. (Suomen uusiomuovi 2009c)

Most of the plastic packages recycled by Suomen Uusiomuovi Oy are PE-LD, PE-LLD, PE-HD films and PE-HD canisters, bottles and boxes. Recycled raw material can be used for the manufacturing of plastic tubes and films and die-casting products whereas PET bottles are used as material in textile industry. New products, like plastic sheets and straps from recycled plastics, need to be generated and the combining of plastic and fibre need to be studied. (Suomen uusiomuovi 2009d).

Producer responsibility organization for wooden packaging

The producer organization for wooden packages is Puupakkausten Kierrätys PPK Oy. The most important product of wooden packages is a loading pallet but e.g. frame works, boxes, casks and cable reels belong this group as well. The recycled wooden material can be used as material in chipboard industry or for new wooden packages. (Puupakkausten Kierrätys (2011)

Producer responsibility organization for metals

The producer organization for metal packaging, Mepak-Kierrätys Oy, (Mepak-Recycling Ltd) was founded in 1997 and registered with the authorities in 1998. The partners of the organization are twelve metal packaging manufacturers, the packing industry and retail-wholesale trade organizations in Finland. Metal packaging includes food cans, paint pails, drums, crown caps, closures, aluminium trays, aerosols, steel bands and straps. Suomen Palautuspakkaus Oy represents deposit based beverage cans. Mepak-Kierrätys Oy has a contract with Kuusakoski Oy, Stena Recycling Oy and Eurajoen Romu Oy in order to ensure the reuse of the tinplate scrap and the registered supplier gets a refund for tinplate and aluminium packages. Mepak has also made a contract with the biggest Finnish waste company Lassila & Tikanoja Oyj to improve the metal collection. Every metal product has over 25 % recycled metal, and saving in energy is 75 - 95 % when using recycled steel instead of virgin raw material. (Mepak-Kierrätys 2011a) There are about 10000 collection points for the collection of household metal. Usually the collected material has been clean enough for recycling, since the small amount of tin is no problem. (Mepak-Kierrätys 2011b)

Producer responsibility organization for fibre-based industrial packaging

Suomen Teollisuuskuitu Oy is the producer organization which is responsible for the recovery of fibre-based industrial packaging in Finland. It was established in 1998. Among other packaging it covers wrappings and end labels for the paper industry, fibre-based wrapping used e.g. for the timber, plywood and steel industries, paper sacks and cardboard cores for rolls. (Suomen Teollisuuskuitu 2011).

Producer responsibility organizations paper

Paperinkeräys Oy is a wholesaler and a producer organization. Companies in the Paperinkeräys Group buy recycled paper, paperboard and cardboard for raw material in the forest products industry. Collection of paper is carried out through local collection points, from residential, commercial and industrial premises, through paper recovery and waste management firms, from printing companies and from other commercial and industrial sources. (Paperinkeräys Oy 2011b) At the moment emptying of collection containers of housing companies is provided by independent collection company. For other residents there are 6700 collection points for paper and carton in Finland which are emptied by Paperinkeräys Oy. Collection points are open 24 hours per day and they are free of charge for citizens. (Paperinkeräys Oy 2011b)

Suomen Keräystuote has been the producer organization for paper since 2005. It was established in 1987 by private paper collection companies and now it is the subsidiary company of Lassila & Tikanoja. The collected paper is mainly used as raw material for newspaper and sanitary tissue in domestic paper industry. (Suomen keräystuote Oy 2011)

Producer responsibility organization for WEEE

SER-tuottajayhteisö ry (**SERTY**) The association of electric and electronic equipment manufacturers and importers, take care of the collection and recycling of waste electric and electronic equipment (WEEE) on behalf of its members in Finland. (SERTY 2011a) SERTY was founded in 2000 because of the changes in the hazardous waste legislation (SERTY 2011b)

Elker Oy is a service company established by the producer organisations SELT Association, ICT Producer Co-operative, and FLIP Association. The above producer organisations have transferred obligations to Elker Oy. (Elker Oy 2010a) SELT Association recycles electrical and electronic equipments (Elker Oy 2010b), ICT Producer Co-operative recycles IT and telecommunications technology equipments (Elker Oy 2010c) and FLIP Association recycling lamps falling within the scope of the WEEE directive (Elker Oy 2010d) Discarded household electrical and electronic equipment are returned to consumer product collection points without fee. (Elker Oy 2010e)

*The European Recycling Platform (**ERP**)* Finland is a producer responsibility organization both for WEEE and portable batteries. ERP Finland was established in 2005 originally under the company name NERA (Association was Nordic Electronics Recycling Association), but has been working under ERP brand since 2009. In 2008 ERP Finland expanded to cover also the producer responsibility on portable batteries. (The European Recycling Platform 2011).

Kuusakoski service points are receiving all the electronic and electric devices from the household as well, for the utilization of metal, plastic and glass. Moreover, many electronic and electric devices include hazardous materials and therefore it is especially important to get them to waste electric and electronic equipment (WEEE) recycling. Recyclable items are for example TV sets, computers, DVD players, refrigerators, washing machines, ovens, phones, heaters, tools, toys, lamps and hobby equipments. (Kuusakoski recycling 2011c)

Producer responsibility organization for end-of-life vehicles

Suomen autokierrätys (**Finnish Car Recycling Ltd**) is producer organization, which co-ordinates the collection, treatment and recycling of scrap cars. Association of Automobile Importers in Finland owns Finnish Car Recycling. (Suomen autokierrätys 2011a).

In the recycling system the vehicle documents and registration and identification data are verified because only the owner can scrap the vehicle. The deliverer of the car gets a certificate of destruction and the vehicle is deregistered. As a pre-treatment in the recycling system the vehicle is dried, i.e. all liquids are removed. Tires, the battery and catalyser are removed and components with a danger of an explosion e.g. airbags, are removed or deactivated. After that, the vehicles are crushed and sorted into three different categories: magnetic steel (raw-material for the steel industry), non-ferrous residue of various metals (processed further into the raw-materials of the metal industry) and light components (recovered as energy or landfilled) (Suomen autokierrätys 2011b).

Producer responsibility organization for batteries and accumulators

Recser Oy is producer organization for portable batteries and accumulators. Retail outlets that are selling batteries and accumulators receive used portable batteries and accumulators from consumers. (Recser 2008).

Akkukierrätys Pb Oy producer organization for the lead acid battery used e.g. in cars. Organization was established by importers Exide Technologies Oy, EnerSys Europe Oy, Koivunen Oy and AkroPower Oy and now over 80 importers of lead acid batteries are joined in Akkukierrätys Pb Oy. Collection of the lead acid battery has been organized in cooperation with Kuusakoski Oy, Lassila & Tikanoja Oyj and Stena Recycling Oy and it has been successful. There are over 600 collections points all over Finland. Materials of batteries are recovered in foundry and they are used again when manufacturing new batteries. (Akkukierrätys 2008)

Producer responsibility organization for used tires

Suomen Rengaskierrätys (**Finnish Tyre Recycling Ltd**) is responsible for the recycling of used vehicle tires in Finland. Company started tire recycling in 1996 and is owned by major Finnish tire manufacturers and importers. (Rengaskierrätys Oy 2011) Pohjoinen rengaskierrätys (North Re-Tyre Oy) is another producer organization for used tires (North Re-Tyre Oy 2010).

Kuusakoski and Suomen Rengaskierrätys take care of the recycling of the used tires in Finland. Annually about 40 000 tonnes of tires is recycled in Finland and the utilization percentage is about 95%, the average percentage of this utilization is ca 60% in Europe. The targets of utilization of crushed tires are elastic groundwork for e.g. riding and sports fields. All the service points of Kuusakoski and tire selling companies receive the tires with and without the band for free, after which they are recycled. (Kuusakoski recycling 2011d) The collection rate of tires was 90% already in 1999. (Melanen et al. 1999)

Appendix 4. Amounts of wastes under producer responsibility

TABLE 17 AMOUNTS OF WASTES UNDER PRODUCER RESPONSIBILITY COLLECTED IN 2006 (YMPÄRISTÖMINISTERIÖ 2010A)

Waste sector	Producer organization	Collected waste (tonnes/a)
WEEE producer organization		38 940
	Flip Ry	946
	ICT-tuottajaosuuskunta-TY	5 336
	Pohjoismaiden Elektroniikkakierrätysyhdistys Ry NERA	11 823
	SELT Ry	546
	Ser-Tuottajayhteisö ry	20 289
Vehicle producer organization		14 183
	Suomen autokierrätys Oy	14 183
	Suomen matkailuautokierrätys	0
Tire producer organization		45 535
	Suomen rengaskierrrätys Oy	44 698
	North Re-Tyre Oy	837
Paper producer organization		355 931
	Paperinkeräys Oy	301 376
	Suomen Keräystuote Oy	54 555
Packagings*		
	Suomen Aaltopahviyhdistys Ry, Suomen Teollisuuskuitu Oy, Suomen kuluttajakuitu Ry, Suomen NP-Kierrätys Oy	225 000
	Suomen Uusiomuovi Oy	15 400
	Suomen Keräyslasiyhdistys Ry	49 600
	Mepak-Kierrätys Oy and Suomen Palautuspakkaus Oy	26 400
	Puupakkausten Kierrätys PPK Oy	15 800

*Amounts of packaging waste include also other packaging waste than collected by using producer responsibility organization system