WWW.JAMK.FI

MAXIMIZING SECONDARY RAW MATERIAL AND ENERGY RECOVERY-SUSTAINABLE LOGISTICS NETWORKING (CASE STUDY)

YAKAH SAMUEL

JANUARY 2013

Degree Programme in Logistics Engineering
Technology, Communication and Transport

JYVÄSKYLÄN AMMATTIKORKEAKOULU
JAMK UNIVERSITY OF APPLIED SCIENCES

JYVÄSKYLÄN AMMATTIKORKEAKOULU
JAMK UNIVERSITY OF APPLIED SCIENCES

DESCRIPTION

Author(s) YAKAH, SAMUEL	Type of publication Bachelor´s	Date 12122012
	Pages 42	Language English
		Permission for web publication (X)
Title MAXIMIZING SECONDARY RAW MATERIAL AND ENERGY RECOVERY-SUSTAINABLE LOGISTICS NETWORKING.		
Degree Programme Degree Programme in Logistics Engineering		
Tutor(s) Värtö-Niemi, Merja, Kervola,Henri.		
Assigned by Lassila & Tikanoja		

Abstract

The objective of the thesis was to study the sustainability of reverse logistics of construction and demolition waste (C&D) and dry waste of the case company and to contribute to sustainable logistics networks design by using a green technology solution in place of the traditional method of processing construction and demolition (C&D) waste and dry waste. The purpose was to maximize the company’s recovery and recycling operation efficiency to make it sustainable.

Reverse Logistics has a great impact on the improvement of the economic and ecological performance of every economy. It seeks to create a balance amongst the three Ps, planet, profit and people in a win-win situation. Reverse logistics starts when the traditional supply chain management ends, and closes the supply chain loop. Compared to traditional supply chain management, close loop management implies saving of raw material and energy which is treated as waste and transported to the landfills. Sustainable development is defined as meeting the needs of the present generation without compromising on the ability of the future generation to meet their needs. Therefore reverse logistics is one form of sustainable development.

Both the qualitative and quantitative research approach was used in this project work. Quantitative research was used to define the problem of the case company and the possible solution. The qualitative part consisted of an account of an in-depth reverse logistics activity of the company and a literature review.

The result of the study showed that, the reverse logistics of construction and demolition (C & D) and dry waste of the case company is not sustainable, and therefore needed a new tool, such as the Zenrobotics Recycler, to maximize its recovery and recycling operations efficiency. The system would probably be implemented in the near future to save the case company from the rising cost of landfilling and to bring cost savings to the case company, as well as save the environment from further damage.

Keywords
Reverse logistics, recycling, sustainable logistics networks, transport, supply chain.

Miscellaneous

CONTENTS

FIGURES

TABLES

1 INTRODUCTION

1.1 Evolution of Logistics

In recent years, one of the fastest growing concerns both at the local and the international level is the potential negative environmental impact of logistics activities such as packaging waste, as a result of its increasing volume and improper disposal. Improper disposal of waste can possibly cause damage to the environment therefore consumers and government have increasingly been concerned about companies to reduce the environmental impact of their products and processes, (Thierry, M., Salomon & J.A.E.E. Van Nunen, L., 1995, 114-135) noted. Researchers have delved into numerous strategies aimed at preserving the environment and their consequences on consumer behavior (Dwyer, Leeming, Cobern, Potter, & Jackson1993, 275-321). One of the widely studied areas of environmental preservation is recycling.

The term logistics has its source in the military. From this perspective it applies to the process of supplying a theater or a battlefield of war with troops, equipment and supplies. The term was adopted in the 1960`s in the business community where it was used to refer to how resources were acquired, transported and stored along the supply chain.

Traditional logistics and supply chain management focused on forward flow of goods and services to the end user. But with the increasing concerns of environmental issues to the government, non-governmental organizations (NGO`S) and consumers, the trend has changed; it is not only forward flow of goods and services to the end user, but also the backward flow of resources along the supply chain to recapture it value for a proper disposal. This is called reverse logistics.(Fernández, 2003), noted that one of the reasons of reverse practices is problem generated from waste; waste in recent years, is a big problem in many countries, due to its increasing volume and lack of landfills, where to dispose it.

Reverse logistics is a fairly new concept in logistics but has gained a lot of attention from both government and consumers due to the current impact of logistics activities on the environment. It is an extension of traditional logistics or traditional supply chain management which seeks to cater for the back flow of resources like products and packaging waste in the supply chain for the purpose of recapturing it value for a proper disposal. There have been many definitions given to reverse logistics, some of which do not consider waste management in the definition where as some definitions consider waste management as part of reverse logistics. In the following chapters the role of waste management in reverse logistics is discussed. Research suggests that there is lack of theory development in the area of reverse logistics, despite it has gained attention in recent years (Dowlatshahi 2000, 143-155).

1.2 Background to the Study (A Small Scale Recycling Company)

Lassila & Tikanoja functions in the field of environmental management, and property and plant support services, and it is the leading supplier of wood-base bio-fuels, recovered fuels and recycled raw materials. Basically there are four main divisions, which include Environmental services, cleaning and office services, property maintenance and Renewable energy Sources. The Company operates in Finland, Sweden Latvia and Russia and has 10,000 employees with the net sales in 2010 amounting to EUR 598 million and in 2011 turnover was 652000000 Euros with 9500 employees. The main competitors of the company include Sihvari, SOL, ISS and Sita.

The small scale recycling company in Jyväskylä is one of the branches within Lassila & Tikanoja, which takes care of the collection and handling of the waste as recycled raw material and energy to other companies. The company deals with recyclable waste recovery and recycling from households and small businesses. Some of the accepted waste transported from households and small businesses to the recycling plant includes recyclable paper, cardboard, wood, construction waste, dry waste, recyclable plastic, burnable waste, and confidential materials.

The company helps its customers in organizing competent environmental management, provides for waste sorting, collection and recycling. The waste collected is processed as recovered recycled raw material and transported to other companies, such as Metsä Tissue. The company uses the recycled raw material for the production of soft tissue papers and handkerchiefs, and to another company called Corenso, which uses it for paper roll core and recovered energy from the waste goes to the energy companies.

2 Reverse Logistics of Source Separated Waste (Case Company)

2.1 Collection and Recovery Systems

The map below in figure 1 shows how the case study company recovers the secondary raw material and energy. On the map it shows different routes with different locations where bins must to be emptied. There are about 163 locations with addresses attached to them, and the driver empties the waste bins within 8 hours depending on the area. With the help of the Track control system (TCS) powered by Ecomond Oy software, the driver could easily drive to the locations and empty the waste bins without missing any of the locations. The system navigates the driver to each location and once the waste bin is emptied, he enters the event into the computer on the truck and the fleet manager in the office is notified that the work has been accomplished. All the information about the route driven by a particular driver is sent in real time. It is possible also to monitor the activities of many drivers using different routes at the same time.

The separation of municipal, commercial and industrial waste streams makes it inevitable that waste and reusable products will be transported over different routes with potentially long distances, storage or processing. Therefore waste management policies aimed at increasing recycling and recovery tonnages will pressurize the transport sector, Resource Recovery Forum (RRF, 2004),the impact of increasing road transport cost on waste recovery and recycling.

FIGURE 1. Map showing different locations of bins (source: Lassila & Tikanoja)

2.2 Sustainable Reverse Logistics

Managing the fleets in the company to transport waste from different locations involves using the Track Control System (TCS) EcomondOy software as earlier on indicated. Transport Control System is a new generation control system for logistics. The software consists of the following applications: mobile terminal, map software, data transferring software, navigation software and office software. TCS has the following functionalities: a map guidance systems for vehicles, route and task data available for the driver, real time controlling and monitoring, using GPS navigation real time connection from vehicles to office and back. These make it easier for the fleet manager to get access to all information concerning the route driven by a driver, Information such as the distance to be driven by a driver, the behavior of the drivers on the road, the speed of the vehicle, the drive time, and the stop times. This is a sustainable way of managing fleet in the company, because drivers do not have to drive any how to consume fuel and time. It reduces the carbon footprints of the trucks to collect and transport   the waste to the processing plant. Figure 2 shows different waste types transported on different roots, which is monitored by the fleet manager with map attached to it as shown in figure 1.

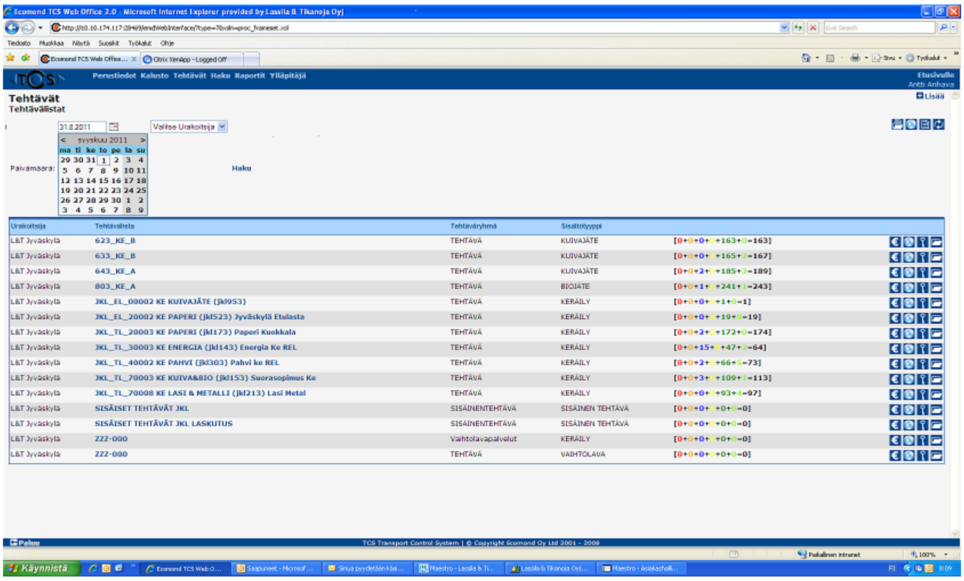

FIGURE 2. Waste types transported on different routes (Source: Lassila&Tikanoja)

2.3 Recovery and Processing of Secondary Raw Material

Source separated waste makes it easier for the company to recover and recycle waste; it goes through the baling process without the need of sorting and separation. The baling of the recyclable waste starts by feeding the conveyor of the plant, once the conveyor is fed manually; it carries the secondary raw material to the plant compartment and then automatically it is compressed into a required size depending on the type of material which is being baled, it includes bottle cans and paper and cardboard. Figure 3 shows source separated secondary raw material being baled.

FIGURE 3.Baled secondary raw material

After the secondary raw material had gone through the baling process, it is formed into cubes, by forming a wire mesh around the raw material and at this stage it becomes heavier and compact with the weight ranging from 300kg to 350 kg. Figure 4 shows the baled material being transported to the warehouse until it gets to the required tons to be transported to other companies, Corenso and Metsä paper.

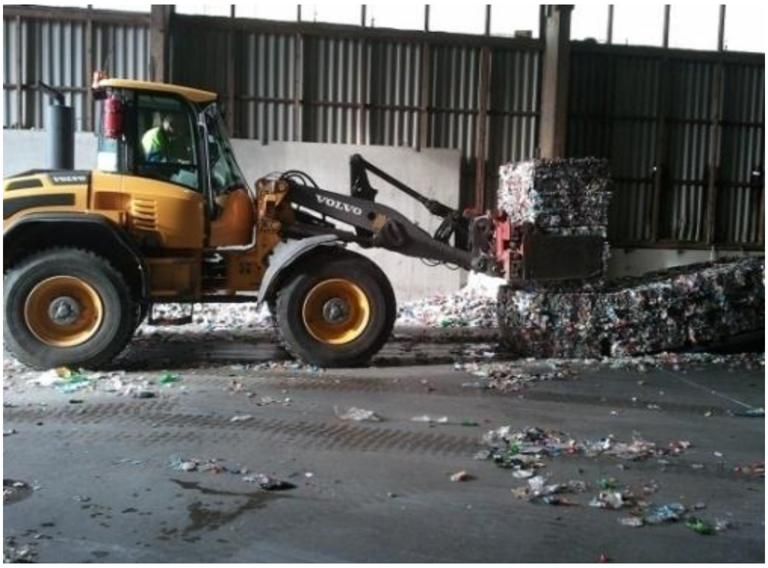

FIGURE 4.Baled material transports to warehouse

2.4 Secondary Raw Material Recovered

The waste is processed as a secondary raw material to be transported to different companies for different uses. Figure 5 shows cardboard recovered and recovered office papers which are being loaded into trucks, to be transported to different companies for the production of different products.

If nothing is flowing back for the purpose of recapturing it value for a proper disposal then the activity may not be considered as reverse logistics. Reverse logistics differs from waste management since in waste management there is no new use of waste collected and processed.

FIGURE 5.Recovered raw material transported to Corenso and Metsä

The recovered cardboard is transported to Corenso and used as a raw material. The picture below shows the products that are manufactured from the recyclable cardboard. Wide range of products can be obtained from the recyclable cardboard and the office papers. In figure 6, a few examples are shown.

FIGURE 6. Some few examples of productsfrom recovered cardboards (Corenso)

2.5 Reverse Logistics and Waste Management

De Britoelet al. (P, Dekker, Rommert & Flapper, Simme D. P., 2003), pointed out that reverse logistics differs from waste management; since waste management is mainly concerned with collection and processing of waste which there is no new use. Waste management plays a major role in reverse logistics as it can be seen from the company's operations. An effective reverse logistics programs are environmentally responsible due to proper storage, collection, disposal and repair of products and as well as the continues improvement approach of minimizing waste ,developing green products and reusing packaging and pallets(Blumberg 1999). Resources in the waste cannot be reversed without waste management. Therefore waste management plays a major role in reverse logistics.

From the definitions of waste management and reverse logistics, the activities of the company on one side, can be considered as a sustainable reverse logistics, a good example is the reverse logistics of the source separated waste indicated earlier on, and on the other hand the construction & demolition (C & D) and dry waste considered as not sustainable reverse logistics. Explanations are given in the following chapters and it forms the basis of the research objective.

3 RESEARCH OBJECTIVES

3.1 Introduction

The objective of the thesis work was to look into the possibility of the company maximizing its recovering of construction & demolition (C & D) and dry waste transported to the facility for processing, and to cut down landfill cost. In this case the company would be able to maximize the reverse flow of the resources in the (C & D) and dry waste rather than managing the waste collected and transported to the company`s facility for processing. This would likely make the reverse logistics of C & D and dry waste sustainable. The dry waste and the construction and demolition (C & D) waste transported to the company are not sorted and separated properly due to the lack of appropriate tool to make the sorting and separation efficient.

In the thesis work, it was suggested that the company may install green technology by Zenrobotic Recycler to separate the raw material from the waste. The new method of sorting and separation by using the Zenrobotics Recycler is likely to maximize the secondary raw material and energy recovery. These are materials which are useful to other companies for the production of valuable products, such as paper core and also other valuable products. The introduction of the new system was expected to cut down tons of recyclable raw materials which are treated as waste and transported to the landfill or otherwise end up in the furnaces.

3.2 Maximizing Recovery and Recycling

The company would recover energy and recycled raw material when especially construction waste and dry waste transported to the company is separated or sorted in efficient manner. The construction waste and dry waste are composed of recyclable secondary raw material, such as the cardboards, wood, plastics and other valuable recyclable materials, and since the company does not use the right tool for sorting and separation, the company processes a small percentage of the waste. The reason is that the company uses excavators for sorting and separating the waste to recover secondary raw materials and energy and the remaining large portion of waste is transported to the landfill. The operation is therefore not sustainable. Figure 7 shows the composition of dry waste in Europe.

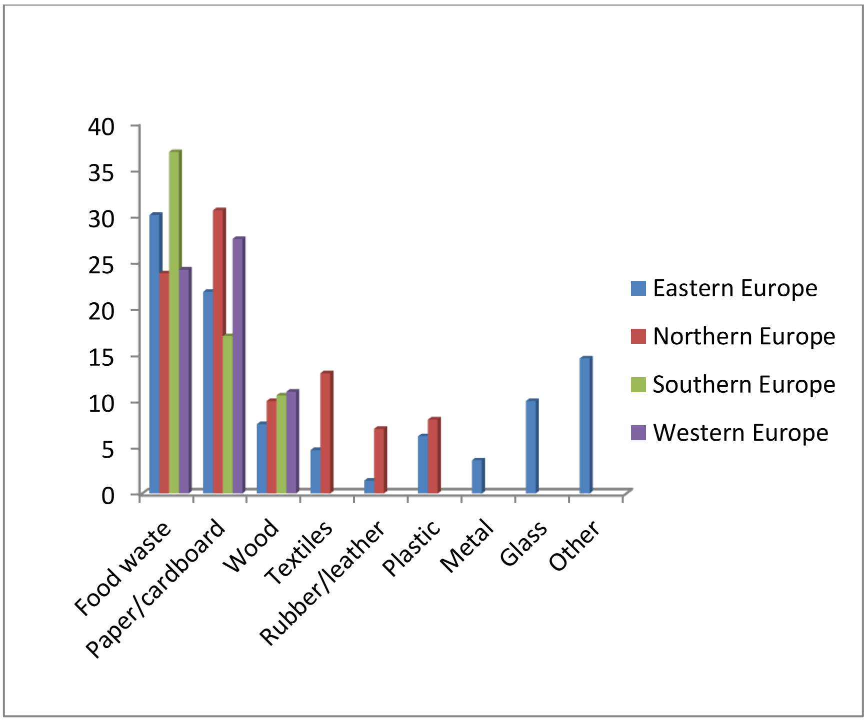

FIGURE 7 . The composition of dry waste in Europe

(Source: 2006IPCCGuidelines for National Greenhouse Gas Inventories)

3.4 Contribution to Sustainable Logistics Networks Design.

It is worth studying the topic because it is part of contribution to the design of sustainable logistics networks. The emphasis was placed on the improvement of the efficiency of the case company sustainable logistics network, by maximizing resources recovery which aims at closing the supply chain loop. It replaces the case company`s traditional supply chain management.

Recovery and recycling of the secondary raw material and energy from the construction waste and dry waste would prevent the virgin forest from further depletion and reserve its natural resources as the population grows. This would result in less demand on virgin materials to manufacture certain products as earlier on indicated.

Making maximum recovery from the waste collected and transported from the construction sites and other households ' dry waste to the company will ensure that there would be availability of virgin raw material resources far into the future for the future generations, rather than transporting it to the landfill sites or ending up in the furnace. This is in line with sustainable development, advocating meeting the needs today without compromising on the ability of the future generations to meet its needs.

The situation in the company was not different from the result from the municipal solid waste management in the whole of Finland, where 53% of waste is transported to the landfill; a target has been set by the Finnish government to reduce landfilling of waste or otherwise resources to not more 20% by the year 2016. The figure 8 below shows the current situation in Finland, and the country needed to recover and recycle more resources rather than managing it (e.g. landfill option)

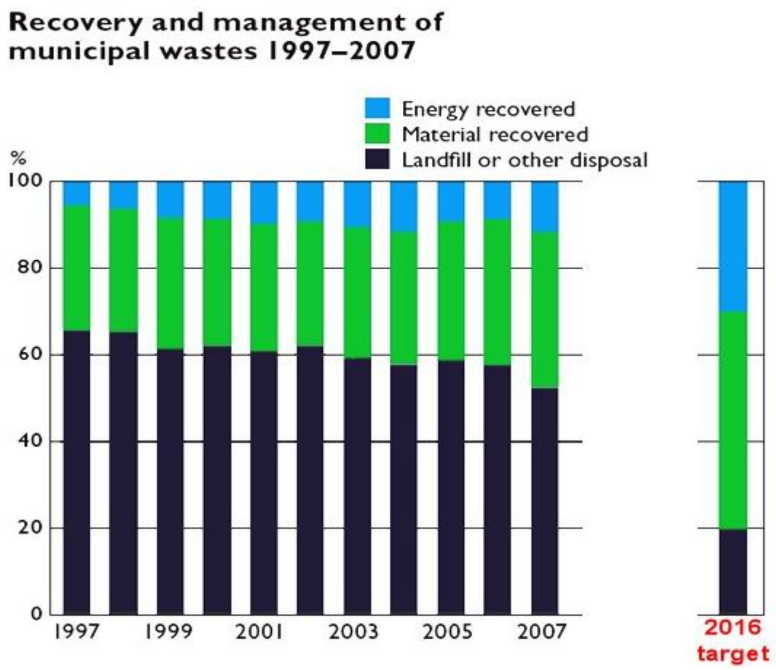

FIGURE 8.Recovery of municipal waste in Finland (Source: Statistics Finland and SYKE. 2008.)

Municipal waste includes the wastes generated by households and comparable wastes produced in industrial, commercial and service premises etc.

3.5 Maximizing Profit and Cutting down Disposal Cost

Improvement in the company`s operations of sorting and separating the raw material from waste would not only save the potential negative impact of its activities to the environment, but rather it would bring cost savings to the company. Figure 9 shows the cost of transporting waste or otherwise secondary raw material to the landfill, due to unavailability of proper method of processing the waste. Depending on the distance, it costs the company 90euros/ton to transport the waste to the landfill, and the fee is expected to rise every year in accordance with EU legislation to make the use of waste or resources for landfilling less attractive.

Recycling, being one of the strategies in minimization of waste, offers three benefits (Edwards, 1999), the first one has been to reduce demand on new resources, the second is to cut down on transport and production energy cost and thirdly to use waste which would be otherwise be lost to landfill sites. (Fleischmann et al.19997*)*, noted that economic and environmental issues are often intertwined. A typical example is, increasing disposal costs makes waste reduction more economical, and environmental conscious customers represent new market opportunities. The use of a new method or tool suggested to sort and separate resources from waste is expected to improve the efficiency of recovery and recycling and save landfilling cost. From May 2011 to January 2012 the case company had to transport most of its construction waste to another branch for processing, or directly to landfill due to new crashing line which took much space for processing, therefore sorting and separation became impossible in 2011.

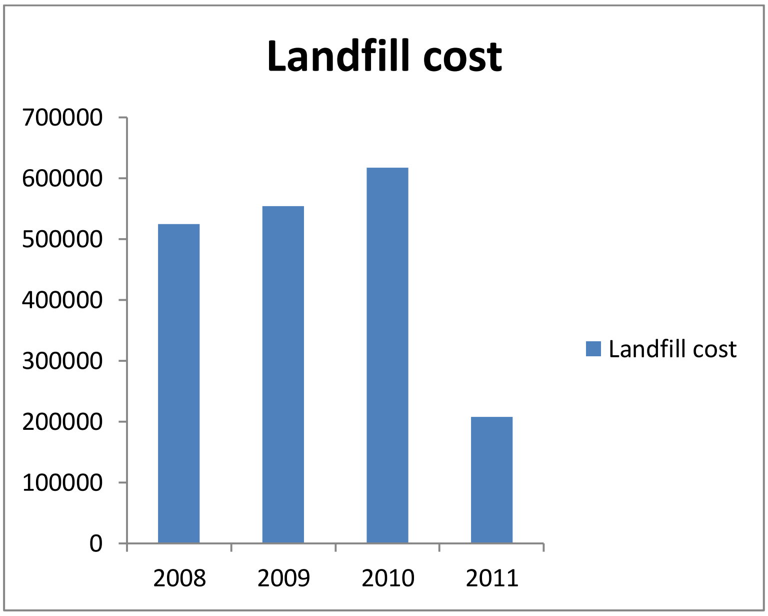

FIGURE 9.The rising cost in Euros of transporting waste to Landfills (Source: Lassila &Tikanoja)

4 METHODS AND MATERIALS

The method for the research consisted of both qualitative and quantitative. The qualitative parts consist of in-depth reverse logistics activities of the company and a literature review, questionnaires were sent to personnel directly on the field of the research topic.

The quantitative study part consisted of problem definition and the cost and benefit analyses. Information was obtained from both companies by exchange of emails. The data collected from case company was used to define the research problem. And the data collected from Zenrobotics Company was used to estimate the cost of installing the Zenrobotics Recycler sorting machine.

The benefits data was collected from the case company and the cost from the Zenrobotics Company to calculate the return on investment (ROI) of installing the Recycler sorting machine.

5 PROBLEM FORMULATION

Production and operations are processes by which goods and services and created. These process or activities can be found in both manufacturing companies and non-manufacturing companies. They have an input which includes materials, parts, paper work form, customers, and training as the case may be and the inputs go through conversion/transformation to generate the output such as the products, services, ideas and skills. The output of production determines whether the operation is productive or not productive.

Figure 10 below shows the situation in the company, where a large percentage of the dry waste and the construction waste transported to the case company is transported to the landfill after processing on the average 17% tons of waste over the four years. This represents a low productivity. Wood waste represents a large component of the construction and demolition (C&D) waste stream, and as such represents a significant opportunity for recycling purposes (Falk, & McKeever, D. B, 2004). Using wood from the construction and demolition waste as land filling has a great potential damage to the environment as these woods are covered with harmful chemicals.

There is therefore the need to maximize the recovery of secondary raw material and energy from the large portion of the landfill waste. If the situation of transporting large percentage of the waste or otherwise unprocessed resources to the landfill persists for number of years, the country would eventually run out of landfills. The reverse logistics activity on this side of the case company is therefore not sustainable. The situation can be seen from figure 10, representing low productivity over the four years.

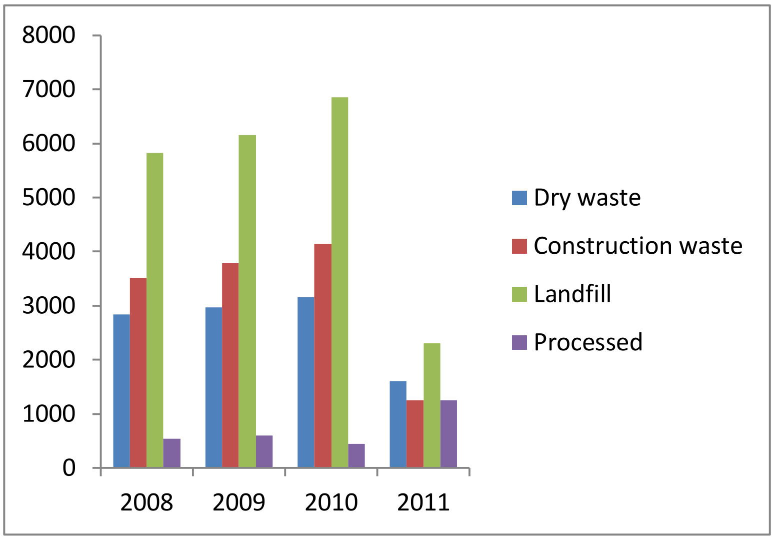

FIGURE 10.Data from processing Construction and demolition waste (C & D) and dry waste (Source: Case Company).

The productivity of the company for the past four years is calculated as follows,

Productivity= output/input

=500+500+400+1200/7000+6000+5800+2200

=17%.

From May 2011 to January 2012 the case company had to transport most of its construction waste to another branch for processing or directly to landfill due to new line which took much space for processing, therefore so sorting and separation became impossible in 2011, as earlier on indicated.

The composition of construction waste is mainly metal, cardboard, wood and different types of plastic. The dry waste is composed of metal, cardboard, wood and plastic, sorting is much more difficult and slower resulting in low productivity. In dry waste nearly everybody packs the waste in smaller or bigger plastic bags before carrying it to bins or containers, which causes problems in sorting. The figure 11 bellow shows a Finnish processing facility, and sorting and separating of raw material from waste before disposal.

FIGURE 11.Finnish waste processing facility (Source: case company)

6 LITERATURE REVIEW

6.1 What is Reverse Logistics?

Reverse Logistics in recent years has attracted a lot of attention from both governmental, consumers and non-governmental organizations (NGO`S), due to the potential negative impact of logistics activities on the environment. Products and packaging waste have therefore become important that, it flows back along the supply chain from the end user to a recovery plant so as to recapture its value for a proper disposal. There are a wide range of definitions given to reverse logistics.

European Working Group defines Reverse Logistics as the process of planning, implementing (De Brito& Dekker, 2004) and controlling backward flows of raw materials, in- process of inventory, packaging and finished goods, from a manufacturing, distributions or use point, to a point of recovery or a point of proper disposal. Despite reverse logistics has gained a lot of attention in recent years both in academia and practice, there is still remains confusion as to its meaning.

(Fleischmann 2001, 156–173), defined reverse logistics as process of planning, implementing and controlling the inbound flow and storage of secondary goods and related information, opposite to the traditional supply chain directions for the purpose of recovering value and proper disposal. Table 1 shows different definitions given to reverse logistics and the changes which have taken place over the years.

TABLE 1 Reverse Logistics Definitions (Source: Pathways to Supply Chain Excellence)

Council of Logistics Management	The term was used to refer to the role of logistics in recycling, waste disposal, and management of hazardous material
Pohlen and Farris (1992)	"...the movement of goods from a consumer towards a Producer in a channel distribution."
Kopicky et al. (1993)	"reverse Logistics is a broad term referring to the logistics management and disposing of hazardous or nonhazardous waste from packaging and products. It includes reverse distribution which causes goods and information to flow in the opposite direction of normal logistics activities."
Kroon (1995)	"are the logistics management skills and activities involved in reducing, managing and disposing of hazardous

	or non-hazardous waste from packaging and products. It includes reverse distribution, which causes goods and information to flow in the opposite direction from normal logistic activities".
Fleischmann et al. (1997)	"a process which encompasses the logistics activities all the way from used products no longer required by the user to products again usable in a market".
Krikke (1998)	"is the collection, transportation, storage and processing of discarded products".
Rogers and Tibben-Lembke (1999)	"The process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or properdisposal."
Dowlatshahi (2000)	"a process in which a manufacturer systematically accepts previously shipped products or parts from the point for consumption for possible recycling, remanufacturing, or disposal".
Guide et al.(2000)	"the task of recovering discarded products (cores); it may include packaging and shipping materials and back hauling them to a central collection point for either recycling or remanufacturing".
European Working Group on Reverse Logistics (RevLog)	"The process of planning, implementing and controlling flows of raw materials, in process inventory, and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal"

6.2 Reverse Logistics and Traditional supply Chain

Reverse logistics starts where traditional supply chains ends. Consumer initially purchases end goods such as a newspaper or soft drink. Once the newspaper is read, or the soft drink is consumed, traditionally, the useful life of the product is ended. Consumers then face the decision of how to properly dispose of any waste material (Jacob, Berning, and Dievorst 1977; Olshasky 1985, 22-28).Reverse logistics therefore is an extended form of traditional supply chain management.

One of the drivers for the implementation of reverse logistics has been the problem generated from waste; waste in recent years have been one of the biggest problems faced by many countries due to its the increasing volume of waste generated and the lack of landfills where to dispose of it .Industrial ecology and life cycle assessment (Green logistics) encompass the environmental side and have been employed to increase recycling behavior and reduce landfill waste (Brockmann 1999, Geyer & Jackson 2004,pp. 36-40).

6.3 Traditional Logistics Models

Supply chain has been traditionally been defined as one way distribution of goods and services along the supply chain from the manufacture to the end user. But due to environmental concerns of government and consumers the model has changed. Due to the fact that government and stake holders are much concerned about the potential negative impact of logistics activities, the issue of sustainable development has therefore become crucial and plays a major role in logistics activities. Figure 12 below illustrates the traditional forward logistics model without products recovery.

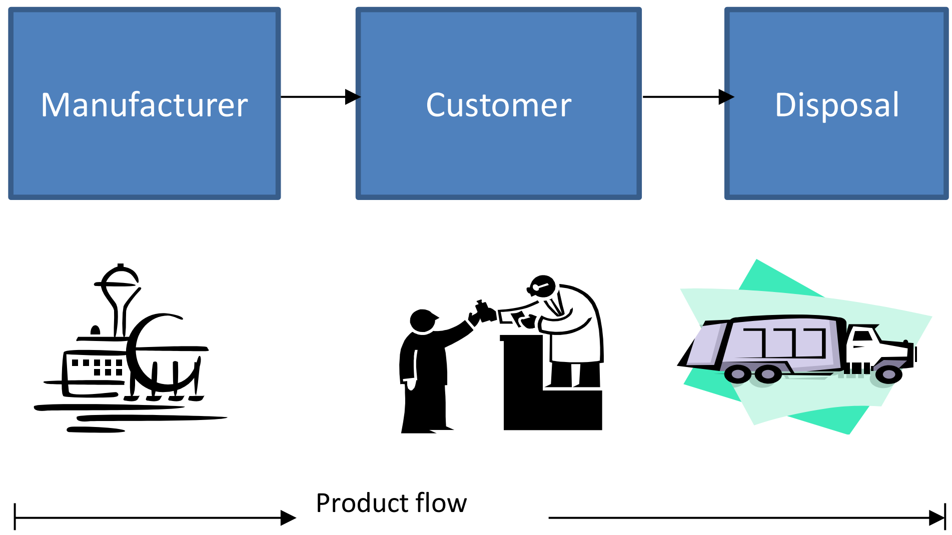

FIGURE 12.Traditional Logistics (IIE Western Region Meeting Jan. 23, 2008)

6.4 Sustainable Logistics Model

Product recovery supply chain model is different from the traditional supply chain as shown below. Resources push or pull through the supply chain flow back for the purpose of recapturing its value before final disposal. The traditional waste management option, such as using resources for landfilling is avoided.The resources are either reuse, refurbish ,recycle and the last option is disposal. Figure 13 shows the supply chain with product recovery model.

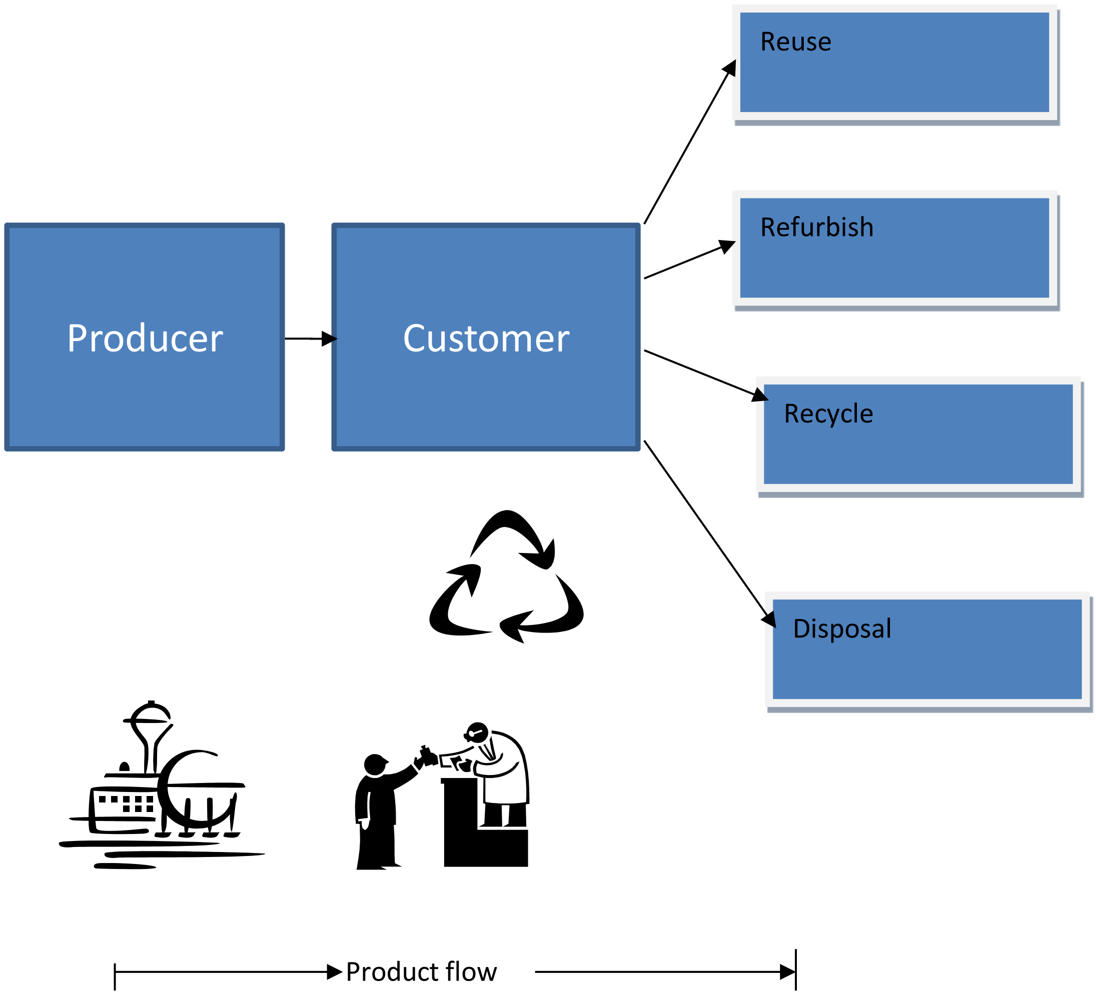

FIGURE 13 Recovery supply chain (IIE Western Region Meeting Jan. 23, 2008)

6.5 Supply Chain Sustainability

The issue of supply chain sustainability has been of a great interest In the last decade, both in academia and in the practitioner`s world. Due to large pressure from various stake holders, especially government regulators, community activist, non-governmental organizations (NGO`S), and global competition, many companies have adopted a certain level of commitment to sustainable practices. Some of these commitments includes, motto like, think Green, Green Office, green logistics and many more others, of which some are compulsory and some are not.

In the light of all these commitments, some companies are still hesitant to commit to sustainable measures, as long as they are not forced to do so by law. (Searcy et al., 2009 (31-42) & Tweed, 2010), noted that, the companies do not have a common standard for evaluating sustainability initiatives. (Lehtinen and Ahola2010, 181-204), think that, there are incompatibilities between the known principles of performance measurements and supply chain dynamics. These suggest that, there is the need for research on developing an appropriate performance measurement in supply chains.

6.5.1 The Size of Company and Sustainability

The adoption of green or sustainable practices in small and medium Enterprises (SME`S) have been identified. And one of the major challenges face in relation to the adoption of sustainable practices in SME`S supply chain was a significant rising cost of greening, Tomomi (2010, 265–280), (Moore &Manring 2009, 276–282), Lee &Klassen (2008, 573–586) and Lee (2008). Large firms have been acknowledged to have an advantage of adopting sustainable practices than SMEs and that SMEs adoption is necessary for long term run.

Sustainability implies different thing to different companies and the size plays a major role in the definition but there is something common which applies to every business, either large or small. Sustainability is a business strategy which has been proven to be profitable; it can be used to create competitive business advantage while at the same time impacting positively on the Environment.

6.5.2 Sustainable Logistics networking

Both consumers and legislation have pushed companies to redesign their logistic networks in order to reduce its potential negative impact on the environment. Sustainable logistics networks evaluate how profitability and environmental impacts are balanced. Many companies have reaped the benefits of environmental-friendly image for pro-actively acting in favor of sustainable development and are able to comply with cumbersome current legislation and also cope with future legal environmental standards. The main activities which are performed along logistics networks are related to manufacturing, transportation, usage and end-of -life products destination.

It is important that the right activities are chosen in modeling specific sustainable logistics networks without losing its explanatory power. In the case of the case study company, the model might exclude disassembling and include rather sorting and separation. The reverse logistics of, for instance mobile phone may include disassembling for its sustainable reveres logistics network design, so it depends on which activity is chosen to model the sustainable logistics network design. The efficiency of sorting and separating the raw material from the waste is very crucial in maximizing its recovery and recycling, thereby cutting down the resources which are transported to disposal, and improving the efficiency of logistics network design of the case company. Literature into logistic networks design is mainly divided into two approaches: minimizing costs or maximizing profits and minimizing environmental impact.

(Francas,D., &Minner, S.2009,757–769) noted that the design of reverse logistics network is difficult problem because of economics aspect and the effects of it on aspects of human life, such as the environment and sustainable of natural resources.

6.5.3 Reverse Logistics of (C & D) waste Dry waste.

The figure 14 represents the hierarchy of disposal options, which categorizes environmental impacts into six levels, from low to high: reduce, recycle, compost, incinerate and landfill (Peng et al., 1997).Recycling, being one of the strategies in minimization of waste, offers three benefits, the first one has been to reduce demand on new resources, the second is to cut down on transport and production of energy cost and thirdly to use waste which would be otherwise be lost to landfill disposal (Edwards 1999).

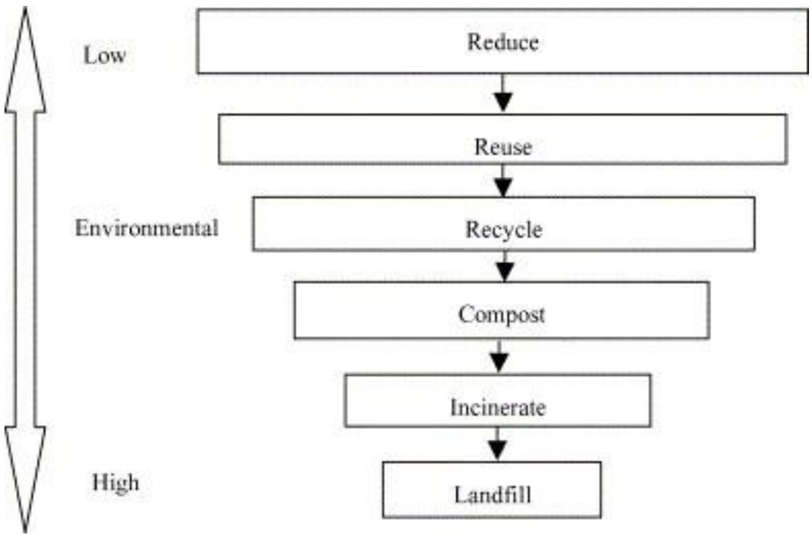

FIGURE 14.Hierarchy of C & D waste (Peng et al., 1997).

The use of construction and demolition (C & D) waste as earlier on indicated for landfilling causes a great damage to the environment as wood represents a large portion of construction and demolition (C & D) waste. In Finland distances between treatment facilities and building wastes are one of the main issues in determining the level to which waste is sorted. As a result of this it is not financially viable to sort waste in Northern Finland as all the main treatment facilities are in the southern Finland (Bio intelligence service) Figure 15 shows modification of sustainable reverse logistics network of the case company which was adopted from Sheu et al. (2005)

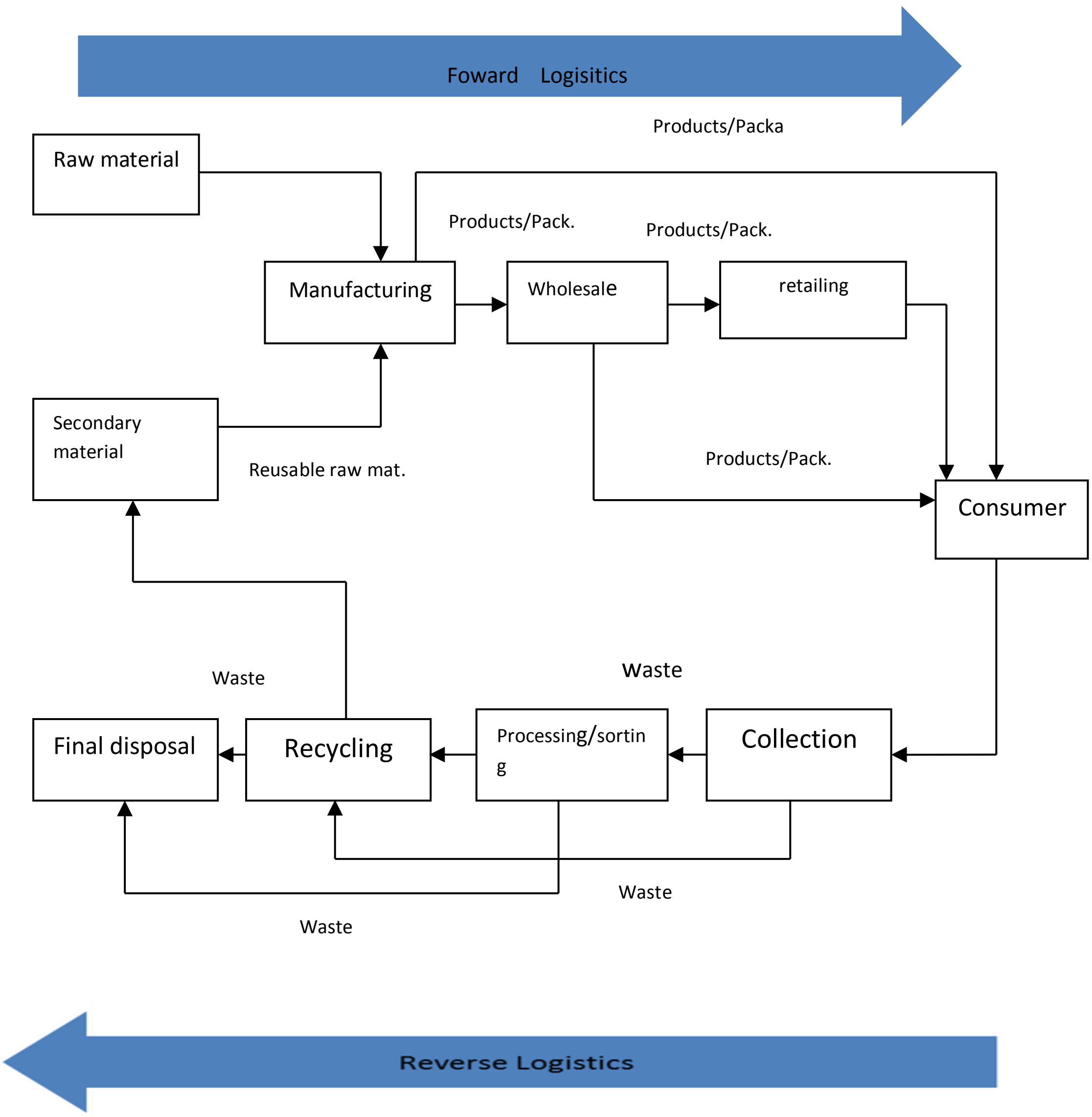

FIGURE 15. Framework for a sustainable logistics network. Adapted from Sheu et al. (2005).

6.5.4 The Role of Legislation in Reverse Logistics

There are many force drivers of reverse logistics; one of the driving forces is legislation. Legislation plays a major role in reverse logistics activities and makes it sustainable. For instance European Member states adhere strictly to European Commission Directive (EC Directive) to achieve its targets. EC Directives seeks to reduce the impact of packaging and packaging waste (94/62/EC) on the environment by introducing recovery and recycling targets for packaging waste, and to encourage in minimization and reuse of packaging. The Directive was meant to set members states mandatory recovery and recycling targets, the first was in 2001. A revised Packaging Directive (2004/12/EC) was published in February 2004 which set new recovery and recycling targets. With the increasing waste management legislation from all members states, more secondary raw material is been recovered instead of ending up in landfills (Aarnio &Hamalainen, 2007). Figure 16 shows the performance from 15 European countries and table 2 shows performance from rates of recovery and incineration of waste plants with energy and recycling rates.

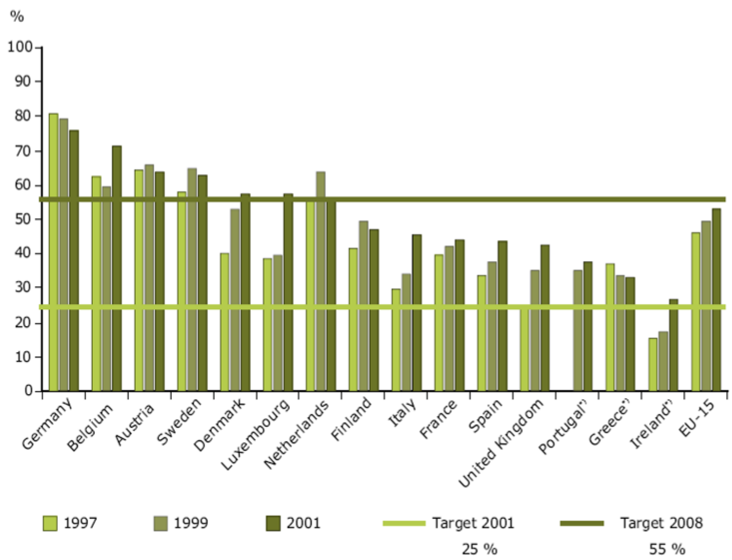

FIGURE 16. Recycling of Packaging Waste until 2001(EEA, 2005)

TABLE2Rates for recovery and incineration of waste incineration plants with energy and recycling rates in 2002 (EC Report Annex, 2006).

	Overall recovery and incineration at waste incineration plants with energy recovery 50%[12, 13]	Overall recycling 25%[14]	Glass 15%[33]	Paper 15%[33]	Metals 15%[33]	Plastics 15%[33]
Austria	75	66	86	80	67	30
Belgium	91	70	93	78	86	29
Denmark	94	57	90	61	44	16
Finland	61	49	49	61	50	15
France	62	45	52	64	53	15
Germany	78	74	86	88	80	49
Greece	33	33	24	68	10	3
Ireland	35	35	48	35	35	17
Italy	56	51	53	59	54	23
Luxembourg	62	57	83	60	79	28
Netherlands	61	57	79	69	80	16
Portugal	50	36	35	50	53	9
Spain	50	44	36	60	39	20
Sweden	67	65	88	70	68	20
United Kingdom	50	44	34	59	39	19

7 AUTOMATED SORTING FOR SEPARATION AND RECYCLING

7.1 Automated Sorting System

The maximum recovery and recycling of construction waste and dry waste cannot be achieved without proper means of sorting and separation. Source separation has been the best option, but, as earlier on indicated, the separation of municipal, commercial and industrial waste streams makes it inevitable that waste and reusable products will be transported over different routes with potentially long distances, storage or processing. Therefore waste management policies aims at increasing recycling and recovery tonnages will pressurize the transport sector (RRF, 2004) .In view of this, source separation of construction and demolition waste (C & D) and dry waste might not be economically viable as it would put pressure on transportation when it has to be transported on different routes; it is therefore important to adopt a system of sorting and separation at the processing plant to make reverse logistics activities economically viable. This will also cut down the carbon footprints of the trucks transporting waste to the processing plant for recycling.

Automated separation system replaces manual sorting and separation, as manual sorting and separation this is problematic in nature, and exposes people to health related problems. The other means of separation, such as the use of excavators do not effectively separate the raw materials from the waste before disposal. It is therefore important that a new method is adopted for sorting and separation in order to maximize the recovery of the resources while minimizing land filling cost.

In general automated sorting systems have been noted to obey two main principles:

-The three dimensional scale
-The Four shell principles

The three dimensional indicates that the automated systems are balance amongst Cost, Capacity and Accuracy. A sorting system could be made to be accurate, thereby giving high quality, but on the other hand, it could be very expensive and limited in capacity. A system can also be designed to be cost effective, but it will not provide sufficient accuracy and capacity for the end user. All the three arms of the scale need to be in balance in order to achieve acceptable sorting system accuracy with a reasonable capacity at a reasonable cost.

Lave et al.(1999) offer an economic –environmental criterion which states that recycling is good policy only if environmental discharges and resources used to collect, sort , and recycle a material are less than the environmental discharges and resources needed to provide an equivalent virgin material, plus the resources needed to dispose of the material safely. Figure 17 shows three dimensional from automated sorting source.

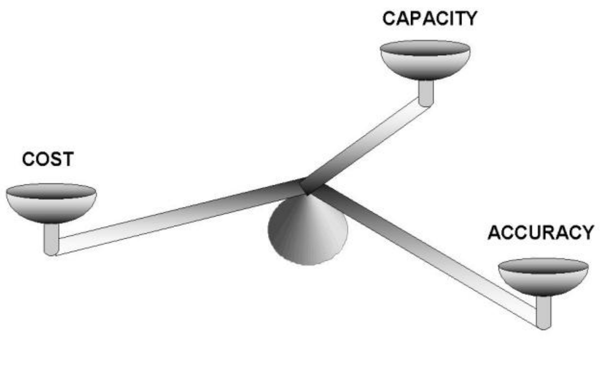

FIGURE 16 . Three dimensional (source: Automated sorting)

7.2 Zenrobotics

The ZenRobotics Recycler is a robotic waste sorting system and it uses machine intelligence to identify valuable raw material from waste. The system separates valuable raw material from waste using artificial intelligence technology; it uses multi sensor inputs to identify items and materials. The sensor includes visible spectrum cameras x-rays 3D scanners.

Unlike any other waste sorting system, the recycler performs different tasks simultaneously; it reclaims raw materials and the same time remove contaminants. It is purposely engineered for construction and demolition waste at the moment and later on be upgraded to sort other waste.

The use of ZenRobotics recycler is currently the option in the recycling and recovery of construction and demolition waste. It is a new concept of recovering raw material from waste. ZenRobotics recovers more materials and increases revenue, and less waste to land fill which leads to large gate fee savings. It is the most advanced technology use by the recycling companies today.

One robot can make 10 - 15 million picks per year. (2500 picks/ hour x 6000 hours). If the average weight of an object in C&D waste is 2 kilos, it will result in a sorting capacity of 20.000 - 30.000 tons per year. Avoiding land filling of 20.000 tons will result in some 2 million Euros of savings. The figure 18 below shows Zenrobotics recycler (ZRR).

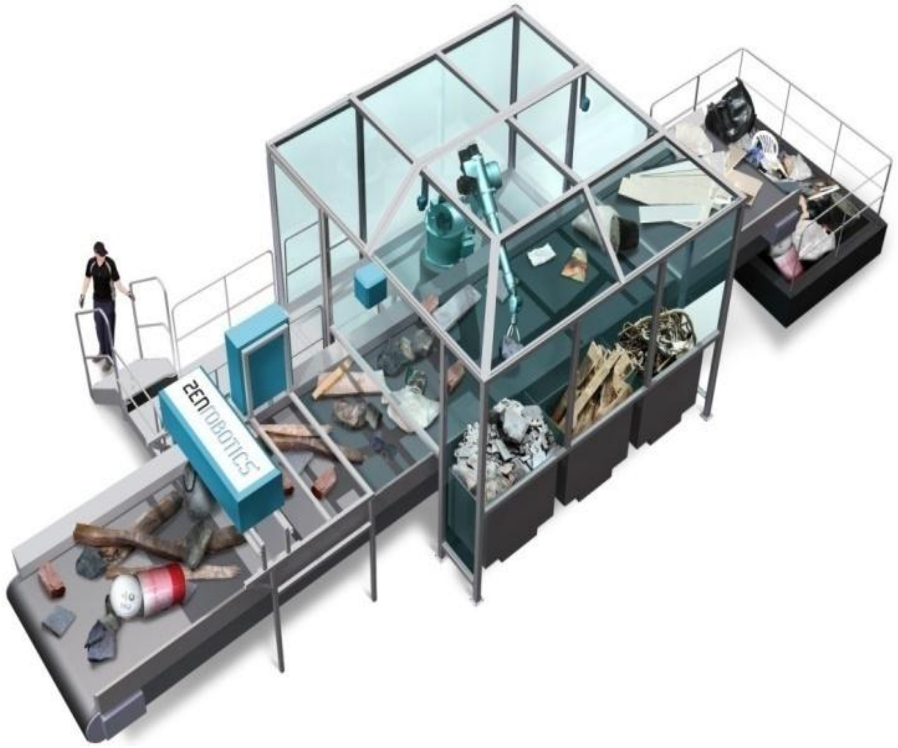

FIGURE 17**.** Zenrobotics Recycler (Source: ZenRobotics)

The Zenrobotics Recycler currently sorts only wood, metals and inert materials (=stone, concrete, bricks etc). Later the ZRR can be updated to process most solid materials. Initially Zenrobotics Company has chosen construction and demolition waste, because it contains a lot of large and heavy objects to sort, and makes therefore robotics sorting effective. And there are not so many good methods available for C&D sorting. There are different types of the recyclers, the figure 19 show another zenrobotics recycler.

FIGURE18. ZenroboticsRecycler (Source: ZenRobotics)

7.3 Cost and Benefit Analysis

Cost and benefits analysis is a simple tool to evaluate the worthwhile of a project to be undertaken and also to determine whether the project should go ahead or not. It is important that the cost of every project is calculated against it benefits, as the name suggests. The cost-benefits involve adding up the benefits of course of action and it is compared to the cost associated with it.

The result is often expressed as payback period, which is the time for the payback. Revenue generation from the recovery of wood, metals and other materials were not included and also the extra cost of installation depending on the site were not included in the calculations. This is due unavailability of data, and as a result of that the payback did not reflect exactly what was expected. The payback is expressed as return on investment (ROI). It is important to indicate here that, the case company would use the savings from landfilling cost to invest in the system.

The sales price of the system is typically 600.000 Euros and cannot be broken into parts, since the system requires the whole package of product. Some additional costs may occur, depending on installation site conditions. The power consumption is some 10 kW. Maintenance fee is 9 Euros per operation hour. The software license fee is additionally monthly 0, 8% of the system sales price.

Table3 Investment Calculations

Investment Cost	600000
People	1
Hourly wages	9 €
Rate cost	1.7
Hours/day	8
Working days/month	21
Months/year	12
Personnel cost	30,844.80 €
Cost of electricity	€ 0.07
Zenrobotics-power consumption	10
Cost of power consumption	€ 0.74
Power cost/year	€ 1,491.84
Invest depreciation	60000
Software license	48000
Yearly cost with investment	€ 140,336.64
Zenrobotics operative cost	€ 140,336.64
Yearly cost without investment(average landfilling cost savings)	467500€
Payback	1.83

ROI= investment cost/Yearly cost without investment -Yearly cost with investment

= 600000/467500-140336
= 1.8

8 RESEARCH IMPLEMENTATION

On the basis of the definitions of waste management and reverse logistics, the reverse logistics of source separated waste, such as the cardboards, empty bottles and cans, office papers of the case company can be considered to be sustainable reverse logistics. On the other hand, the processing of construction and dry waste is not a sustainable reverse logistics and has potential damage to the environment and needs to be tackled. The traditional method of processing the waste by using excavator is not sustainable because, enough resource recovery is not achieved before the waste is transported to the landfills and that results in a low productivity. This rather put pressure on transport. If the recovery of resources from the waste is maximized, it would cut down the transportation routings of the case company; the carbon footprint of the trucks would also be reduced.

When the operation of the case company continues for some number of years without implementing a new tool, for sorting and separating the resources from the waste transported to the landfills, the country would eventually run out of landfills. It is obvious that that the most challenging part of the company`s operation is sorting and separation of the construction and demolition (C & D) and it needs improvement.

Green technology, such as Zenrobotics recycler has made it easy to recover and recyclable resources which were used as landfilling or end up in the furnaces.

Implementing green technology, such as Zenrobotics recycler has so many advantages, industrial robots sort the waste which replaces the manual sorting by hand which is problematic in nature and has been banned in Europe.

Data was collected from the case company, from the fleet manager of the company to access the company`s operations over the past fours. The analysis of the data collected showed that, the case company faces a big challenge in the processing of construction & demolition and dry waste. The answer from the fleet manager from one of the questionnaires sent stated, ``the composition of construction waste is mainly metal, cardboard, wood and different types of plastics. The dry waste is composed of metal, cardboard, wood and plastic; sorting is much more difficult and slower. In dry waste nearly everybody packs the waste in small or bigger plastic bags before carrying it to bins or containers, which causes problems in sorting and separation``. This justifies that the case company indeed needed a new tool to improve its operations. All the information gathered from the case company and Zenrobotics Company has been utilized to come out with the result.

9 RESEARCH ANALYSIS AND RESULT

The result of the research showed that the case company`s reverse logistics of construction and demolition (C & D) and dry waste operations are not sustainable. The operation has a potential damage to the environment as large portion of C & D waste and dry waste is used as land filling. Therefore there is a need for the case company to adopt a different method rather than the traditional method of sorting and separating of secondary raw material from waste before final disposal.

A new tool, such as Zenrobotics Recycler was found to be the solution to the current problem face by the case company. Zenrobotics is a Finnish company situated in Helsinki, Finland. The company specializes in robot sorting of waste. The use of robots is not known in waste sorting but well known in automobile industries. Today, Zenrobotics recycler has brought the benefits enjoy by the automobile industries to waste recycling companies. The use of robot can reclaim clean, specific fractions whiles improving the efficiency of the existing waste processing facility. This prevents important raw materials from ending up in landfills and furnaces. Sorted objects are reclaimed and sold.

The system balances well amongst cost, capacity and accuracy. One typical example of the Zenrobotics Recycler has the capacity that exceeds the capacity which the case study company currently deals with; the system can make 10-15million picks per year, which will result in 20.000 -30.000 tons and the capacity of the case company on the average is 4000 tons of construction and demolition waste 3000 tons of dry waste in 2010. These are far less than 20,000 to 30,000 tons; different types of these systems are available to suit the case company's capacity.

The case company in 2010 spent as much 600,000 Euros to transport waste to landfills, equal to the price of the Zenrobotics system which is 600,000 Euros. The cost of land filing is expected to rise in the years ahead to make waste management option such as using waste or otherwise resources as land fillings less attractive. Therefore increasing the efficiency of reverse logistics of construction and demolition(C&D) waste and dry waste of the case company by adopting a new tool to increase its recovery operations efficiency is the way out to save the planet, make profit and save people and in a win-win situation.

10 DISCUSSION AND CONCLUSION

In this thesis, it was pointed out that, forward logistics has evolved over the years. It was also pointed out that reverse logistics is different from waste management as in the latter there is no new use. Reverse logistics activities is one form of sustainable logistics or sustainable development, but waste management is not.

The main objective of the thesis was to explore the possibility of maximizing the recovery and return flow of resources from waste and to make the case company reverse logistics of C & D and dry waste sustainable or greener. The case company was used to showcase the important role waste management can play in reverse logistics. Reverse logistics as earlier on indicated, is a new concept but has gain a lot of attention due to the potential ecological impact of logistics activities. It replaces the traditional forward logistics with recovery of resources from the consumer for the purpose recapturing its value for a proper disposal. If nothing is flowing back for the purpose of recapturing its value, then the activity may not be reverse logistics.

There are a lot of activities which go into modeling Sustainable logistics network designs, it could be the back flow of products, equipment, materials, packaging or the entire technical systems to be recovered for proper disposal. Not necessarily the resources flowing back to the manufacture as some definitions may suggest, but could also be transported to a different destination all with the purpose of recapturing it value for a proper disposal. In the case company, reverse logistics of construction and demolition waste (C& D) and dry waste was used in modeling the sustainable logistics network.

Construction and demolition (C & D) and Dry waste needed a green technology to sort and separate rather the traditional method of sorting and separation. The using of the excavator for processing the C & D and dry waste is a form of barrier to its reverse logistics and resulting in managing the waste or otherwise not sustainable.

Finally, implementation of a new tool for sorting and separating resources from waste, such as Zenrobotics recycler, is expected to bring huge savings to the case company by cutting down the rising cost of landfilling and the make the case company operations sustainable. This might prevent the Environment from further damage.

REFERENCES

Aarnio, T., Hamalainen, A. (2008, pp 612–621.) Challenges in packaging waste management in the fast food industry. Resources, Conservation and Recycling, 52.

Action 4 report final. Accessed on November 25 2012. http://www.eng.ucy.ac.cy/rept/PROGRESS/Action%204%20report%20final.pdf

Blumberg, D. F. (1999, pp141-159). Strategic examination of reverse logistics and repair service requirements, needs, market size, and opportunities. Journal of Business Logistics, 20 (2), Bowman, R.

Brockman, T. (1999, pp 36-40). 21 warehouse trends in the 21st century. IIE Solutions, 31 (7).

Dekker, Rommert, Jacqueline Bloemhof& LoannisMallidis.no3 (June 16,2012, 671-679).Operations Research for Green Logistics –An Overview Aspects of, Issues, Contributions and Challenges. Europeans Journal of Operational Research 219.

De Brito, M. P., Dekker, Rommert& Flapper, Simme D. P. (2003).Reverse Logistics.A Review of Case Studies.

Dowlatshahi S. (2000, 143-155.).Developing a theory of reverse logistics, Interfaces, 30.

DyckoffHarald, Richard Lackes& Joachim Reese (2004, 163-177). Springer, Berlin; New York. Supply Chain Management and Reverse Logistics.

DEBRITO.Accessed on October 02 2012.

http://repub.eur.nl/res/pub/1132/EPS2004035LIS_9058920585_DEBRITO.pdf

Dwyer, W. O., Leeming, F., Cobern, M. K., Porter, B .E.,& Jackson, J. M. (1993, 275-321). Critical review of behavioral interventions to preserve the environment: Research since 1980. Environment and Behavior, 25 (3),.

Edwards, B., 1999. Sustainable architecture: European directives and building design. 2nd ed., Oxford: Architectural Press.

EcomondOy. Assessed on December 08 2012.http://www.ecomond.com/en/?Products:TCS

FrotaNeto, J. Quariguasi, J.M. Bloemhof-Ruwaard, J.A.E.E. van Nunen&E.van Heck.no.2 (Febbruary 2008,195-208).Designing and Evaluating Sustainable Networks. International Journal of production Economics 111.

Feweco. Accessed on October 09 2012.http://www.ymparisto.fi/download.asp?contentid=105175&lan=fi

Fernandez, I. (2003). Household waste collection: a case study. LOADO'2003.

Fleischmann, M., 2000. Quantitative models for reverse logistics. Ph.D. Thesis, Erasmus University.

Falk, R. H. &McKeever, D. B. (2004).Recovering wood for reuse and recycling, a United States perspective. Proceedings from the 2004 EuropeanCOSTE31Conference.http://www.woodweb.com/knowledge_base/Recovering_wood_for_reuse_and_recycling__a_United.html

Fleischmann M., J.M. Bloemhof-Ruwaard, R. Dekker, E. van der Laan, J.A.E.E. van Nunen& L.N. van Wassenhove (1997,103:1-17), Quantitative models for reverse logistics: a review, European Journal of Operational Research.

Francas, D., &Minner, S. (2009, 757–769). Manufacturing network configuration in supply chains with product recovery.Omega, 37(4).

Fleischmann, M., Beullens, P., Bloemhof-Ruwaard, J. M., & Van Wassenhove, L. N. (2001, 156–173). The impact of product recovery on logistics network design.Production and Operations Management, 10(2).

Huan,Wen-Ling,Dung-Hung Lin,Ni-Bin, &Kuen-Song Lin.no.1(December 2002,23-37).Recycling of Construction and Demolition Waste via a Mechanical Sorting Process. Resources and Recycling 37.

Kopichy, R.J.; Berg M.J.; Legg L.; Dasappa V. &Maggioni C. (1993)," Reuse and re cycling: reverse logistics opportunities", Council of Logistics Management, Oak Brook, IL.

Resource Recovery Forum (RRF 2004)The Impact of Increasing Road Transport Cost on Waste Recovery and Recycling , a report for the Resource Recovery Forum by Ceres Logistics RRF,Skipton.

Sheu, Juih-Biing,Yi-Hwa Chou,& Chun-Chia Hu (July 2005,287-313).An Integrated Logistics Operational Model for Green-supply Chain Management. Transportation Research Part E: Logistics and Transportation Review 41.

Searcy, C., Karapetrovic, S., McCartney, D., (2009, 31-42). Designing corporate sustainable development indicators: reflections on a process. EnvironmentalQuality Management 19 (1).

Southampton. Accessed on October 29 2012.http://www.greenlogistics.org/SiteResources/c566b714-1f55-416e-99af-9aab1b4cd2cc_WM10%20-%20Southampton%20-%20Reverse%20Logistics.pdf.

Tam,Vivian W.Y., & C.M. Tamno.3 (June 2006, 209-221).A Review on the viable Technology for Construction Waste Recycling.Resources, Conservation and Recycling 47.http://www.sciencedirect.com/science/article/pii/S0921344905001746.

Thierry et al., (1995, pp. 114–135), M. Thierry, M. Salomon, J.A.E.E. Van Nunen, L. Van Wassenhove.Strategic issues in product recovery management.California Management Review, 37 (2).

Tomomi, T., (2010, 265–280). Environmental management strategy for small and medium- sized enterprises: why do smbs practice environmental management? Asian Business and Management 9 (2).

Tweed,K.,September29,2010.Sustainabilitypracticesarereallyriskmanagement./http://www.greentechmedia.com/articles/read/sustainability-is-real ly-risk-management/.

Jacoby, Jacob, Carol K. Berning& Thomas F. Dietvorst (1977, pp. 22-28), "What about Disposition?" Journal of Marketing, (April), Proceedings of the Congress.

Lave etal.,(1999)Lave LB, Hendrickson CT, Conway-Schempf NM & McMichael FC. Municipal Solid Waste Recycling Issues. Prepared by Carnegie Mellon University for the United States Environmental Protection Agency under Cooperative Agreement #CR825188-01-2, Washington,DC: http://yosemite.epa.gov/ee/epa/eermfile.nsf/vwAN/EE-0420-01.pdf/$File/EE-0420-01.pdf

Lassila&Tikanoja.Accessed on 15 September 2012.http://www.lassila-tikanoja.fi/en/Pages/Default.aspx

Lee, S.-Y.&Klassen, R.D.(2008,573–586), Drivers and enablers that foster environmental management capabilities in small- and medium-sized suppliers in supply chains. Production and Operations Management 17 (6).

Lehtinen, J., Ahola, T., (2010, 181-204). Is performance measurement suitable for an extended enterprise? International Journal of Operations and Production Management 30 (2).

Moore, S.B. &Manring, S.L., (2009, 276–282). Strategy development in small and medium sized enterprises for sustainability and increased value creation.Journal of Cleaner Production 17 (2).

Pengetal, (1997, pp. 49–58), C.L. Peng, D.E. Scorpio, C.J. Kibert. Strategies for successful construction and demolition waste recycling operations. J. Construct. Manag.Econ., 15 (1).

Pohlen T.L. & Farris, T. (1992, 22(7):35–47), Reverse logistics in plastics recycling. International Journal of Physical Distribution & Logistics Management.

Waste_Data.Accessed on 25 October 2012.http://www.ipccnggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_2_Ch2_Waste_Data.pdf.

WrightRE_Web12.Accessed on October 06 2012.http://www.na-businesspress.com/JABE/WrightRE_Web12_5_.pdf

Zenrobotics.Accessed on 20 October 2012
http://www.zenrobotics.com/english.

APPENDICESS

Appendix 1 Questionnaire (case company)

Data collection was done through the exchange of emails to the case company and Zerobotics Recycler Company in Helsinki.

Questionnaire

-How many tons of dry waste and construction waste are transported to the company in each year?

-How much tons of recycled raw material the company is able to process out of the dry waste and construction waste and

-How many tons of waste transported to the landfill?

- What is the composition of construction waste and dry waste?

-Could you give me any estimation of ton of cardboard and other recyclable materials that could possibly be recovered if the dry mixed waste and the construction waste are separated properly?

-Turnover of the company and the current number of employees

-Competitors of the company

Last year, In L &T Jyväskyläprocessed, 1.1.2011 – 31.12.2011

Dry waste 1604, 02 tons

Construction waste 1952, 60 tons

Transported to Landfill 2305, 24 tons, so we processed 1251, 56 tons

It is really difficult to estimate the amount of cardboard and other recyclable materials in construction waste.

Turnover in 2011 was 652 000 000 € and in 2011 L&T had 9500 employees.

The Cost per/ ton transported to landfill is about 90 €.

Appendix 2 Questionnaire (Zenrobotics Company)

Questionnaire

The diagram below shows the composition of dry waste in Europe, Finland falls in the northern sector, could you give some details regarding how the Zenribotics system separate the important materials in the waste for recycling. The company uses excavator and therefore could not separate the raw materials from both the construction waste and the dry waste.

RR: Currently we sort only wood, metals and inert materials (=stone, concrete, bricks etc.). Later the Zenrobotics can be updated to process most solid materials. Initially we have chosen construction and demolition waste, because it contains a lot of large and heavy objects to sort, and makes therefore robotics sorting effective. And there are not so many good methods available for C&D sorting.

RR: as we have a unique product with no real competition, I would say it is not so easy to position us. Of course the unique feature is that the ZRR can produce better quality for the sorted fraction, than what is possible by other means. So quality is what we might focus most on.

The sales price is typically 600.000; the whole package of product. Some additional costs may occur, depending on installation site conditions.

The power consumption is some 10 kW. Maintenance fee is 9 Euros per operation hour.

Software license fee is additionally monthly 0, 8% of the system sales price.