TALLINN UNIVERSITY OF TECHNOLOGY

FACULTY OF CIVIL ENGINEERING

DEPARTMENT OF ENVIRONMENTAL ENGINEERING

ASSESSMENT OF POSSIBILITIES OF HAZARDOUS WASTE UTILIZATION IN AS NORMA

AS NORMA'S TEKKIVATE OHTLIKE JÄÄTMETE UTLILISEERIMISE VÕIMALUSTE HINDAMINE

EKV70LT

Student: Erika – Henriet Aus .....

Supervisor: Viktoria Voronova .....

Co-Supervisor: Hakan Berber .....

Tallinn, 2016

I have prepared the Master's thesis independently.

All papers of other authors, major opinions, and data originating from bibliographical and other sources have been referred.

…… (signature of the author and date)

Student code: 131770

The thesis meets the requirements set to a Master's thesis.

…… (signature of the supervisor and date)

Permitted to the defense ……. (date)

Chair of the defense committee ……..……. (signature)

Tallinn University of Technology

Department of Environmental Engineering

TASK FOR FINAL THESIS

Student's code:	131770EABMM
Student specializing in Environmental Engineering:	Erika – Henriet Aus
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Supervisor for the thesis:	PhD Viktoria Voronova
	MSc Hakan Berber

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AS Normas tekkivate ohtlike jäätmete utiliseerimise võimaluste hindamine.

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Initial data

- Waste Act, 3.11.208
- Jäätmete ohtlike jäätmete hulka liigitamise kord; 06.04.2004 määrus nr 103 (Procedure for the classification of waste as hazardous waste)
- Directive 91/689/EEC EU Hazardous Waste
- List of Waste 200/532/EC
- Waste Framework Directive 75/442/EE
- Vabariigi Valitsuse 26. aprilli 2004 määruse nr 121 "Ohtlike jäätmete käitluslitsentsi andmise, muutmise ja kehtetuks tunnistamise menetluse käigus läbiviidavate menetlustoimingute tähtajad, litsentsi taotlemiseks vajalike andmete loetelu ja litsentsi vorm"
- All tegevus valdkondade loetelu ning künnisvõimsused, mille korral on käitise tegevuse jaoks nõutav kompleksluba
- Keskkonnakompleksloa taotluse ja selle lisade vormid ning keskkonnakompleksloa sisu täpsustavad nõuded ja vorm
- AS Norma Jäätmekäitlus standard QMS 70 (Waste Management Standard)
- AS Norma Jäätmete käitlemise juhend HAO 04 (Waste Management guide)
- Industrial emissions law
- AS Norma Integrated environmental permit

Content of the thesis

Objective of this thesis is to analyze AS Norma current hazardous waste (in this thesis six waste types emerged in production and are classified as hazardous are discussed) collection and transfer to find out the best possible methods of its utilization. It involves finding the most suitable scheme of waste disposal that is financially profitable to the company and offers complex solutions. Thesis gives an overview about legal requirements have to be met both by AS Norma and waste handling companies.

The thesis aims also to identify current market situation. How many companies need licenses and in addition to prices what are so called soft values that these companies offer (environmental view and complex solutions).

This thesis is innovative because at the moment company has no overview of potential cooperation partners that can provide hazardous waste handling service. This analyze is profitable to the company both in financial and environmental way and may help the company make a better decision when choosing partners.

Explanatory letter

Summary in English

Aim of this thesis is to analyze current hazardous waste disposal methods in manufacturing company AS Norma and give a brief overview of market situation. Today AS Norma uses different companies to dispose their waste. As the waste is classified as hazardous the obligation is to give the waste to companies that have a special permit for handling waste. At the moment the company has no clear overview of the service and disposal options on the market. It is necessary to analyze different opportunities that can be profitable and find out a possibility for improvements.

Resümee eesti keeles:

Antud lõputöö eesmärk on analüüsida tootmisettevõtte AS Norma ohtlike jäätmete käsitlemise meetodeid ning anda lühike ülevaade turul olevatest teenuspakkujatest. Hetkel kasutab AS Norma erinevaid ettevõtteid oma jäätmete utiliseerimiseks. Kuna ära antavad jäätmed klassifitseeruvad kui ohtlikud jäätmed lasub ettevõttel kohustus anda need ära teenusepakkujatele, kes omavad ohtlike jäätmete käitlemiseks vastavat litsentsi. Hetkel puudub ettevõttel selge ülevaade turul pakutavatest utiliseerimise teenustest ja võimalustest. Selleks on tarvilik analüüsida erinevaid võimalusi, mis võivad ettevõttele olla kasumlikud ning uurida välja kas kasutatavates meetodites on võimalik teha parendusi.

Graphic material:

There are 10 figures and 13 tables in these theses

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Supervisor	Viktoria Voronova	…….
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List of Abbreviations

HW – Hazardous Waste

HWD – Hazardous Waste Directive

WO – Waste Oil

WM – Waste Management

LoW – List of Waste

MSW – Municipal solid waste

EU – European Union

WFD – Waste Framework Directive

BAT – Best Available Technology

WFD – Waste Framework directive

WTP – Waste Treatment Plant

OECD – Organization for Economic Cooperation and Development

CBA – Cost-benefit analyze

WHC – Waste Handling Company

NPV - Net Present Value (NPV)

IRR - Internal Rate of Return

BCR - Benefit-Cost Ratio

BEP - Break-even point

HMS 1 – Heavy melting scrap

MHS 2 – Heavy melting scrap containing galvanized and blackened steel

1. Introduction

AS Norma incorporates various processes starting from product development and tool-making to modern automated manufacturing. The technologies available to customers include sheet metal progressive stamping - including fine blanking, plastic injection molding, electroplating, and various assembly operations.

The starting point of the study was the need for an evaluation and suggestions for ways to optimize hazardous waste collection and transfer financially and economically better way. At the moment different companies have permit to handle waste. Decision of selecting cooperation partners is based on previous experiences, legal license and offered prices. No further market researches of service providers or analyzes have been made. This study aims to collect sufficient information to ease the decision making when choosing cooperation partners in future. The focus of this master thesis is to analyze current system and cooperation partners of AS Norma and choose the best option for hazardous waste utilization.

To make the assessment following background information is needed:

- Review of regulations that have to be met by both AS Norma and cooperation partners
- Market research of companies that can provide needed services
- Prices of services
- Environmental views of service providers
- Complex services – multiple services provided from one service provider

The company is interested mostly in waste types listed below. The focus is on these wastes because the handling of these waste is regulated by law more strictly and legal license is needed for the service provider to handle the waste. As the business sector of AS Norma is not very common in Estonia then there may not be so many service providers or the information hasn’t been so widely available.

These wastes are classified as hazardous waste and need specific measures of handling and disposal. For addition to legal requirements the waste needs to be monitored and handled according to integrated environmental permit. [1]

List of waste:

- Surface treatment sludge
- Salt waste from tempering processes
- Washing liquids
- Waste oil
- Filter materials
- Steel scrap

The waste listed are types of waste that emerge of various processes of making final product. They cannot be eliminated only minimized and controlled by using best possible technology and the amount of waste rises with rise of production growth.

Scope of the study

The main aim of the thesis is to find possible solutions for hazardous waste utilization in AS Norma.

The study evaluates all the aspects including economical, legal and institutional to find the best solution. The outcomes of the thesis could lead to exhaustive analyze of further waste handling opportunities that can both be profitable from financial term and can save time in collection and transferring side. To collect the data an overview of existing companies in the market should be provided. Exhaustive study of market will be made considering all companies that have legal permits to handle all types of hazardous waste generated in the company. List of companies will be made and analyzed by license extent and the prices that they offer.

The Cost Benefit Analyze will be created to assess economical and systematical values to estimate the strengths and weaknesses of used solutions and alternatives. It helps to determine the feasibility of the project economically and can provide guidance when making decisions.

The basic ideology of handling hazardous waste is to collect and utilize them in the most environmental friendly way by choosing a proper service provider. At the moment different companies have permit to handle hazardous waste. It is reasonable to search and analyze the opportunities to find service providers that have wider legal permits and can receive all hazardous waste at once. This kind of approach can minimize the labor payments and working time of the company and indirect environmental impact.

To gather an information desk research was carried out. Information was gathered via additional search (official websites, guidance, public reports etc.).

The first step in this process was to identify relevant stakeholders. Personal interviews, by telephone or by e-mail have been conducted with the stakeholders identified. The aims of the interviews were to collect more information, to assess the quality of already collected information (via desk research, summarized in the draft factsheet). Also to obtain additional information about soft values of the company – environmental approach and services.

To assure the environmental sustainability AS Norma has been certified according to environmental management system based on ISO 14 001 and is committed to follow the principles and commitments established by the standard. Part of that the company has obligation to implement their business decisions in environmentally responsible and caring manner relative to company's employees, customers and communities and to comply with the legislation of the Republic of Estonia and meet customer's and other requirements, applicable to the activities of AS Norma and related to the environmental aspects of the company.

2. Theoretical background

In this chapter, two main parts have been reviewed. As a first step, relevant theoretical background on hazardous waste (HW) legislation in European Union is provided. To continue with relevant legislation, regulations in Estonia are discussed and at the end of the chapter possible treatment methods for HW are described.

2.1. Hazardous Waste legislation in European Union

The European Union has given out the EU Hazardous Waste Directive 2008/98/EC (HWD). The scope of the directive is to approximate the laws of the Member States on the Controlled management of hazardous wastes. Hazardous wastes are defined as waste that is dangerous or potentially harmful to our health or the environment.

According to the EU HWD, waste hierarchy presents the most favorable option and least preferred option of waste handling as it is shown in figure 1. The main purpose of this pyramid is to get maximum benefit from materials and produce the minimum amount of waste. [2]

Figure 1: Hazardous waste management hierarchy [3]

Additionally, the HWD set up targets in waste management for the Member States:

- When disposed the waste is recorded and identified
- Mixing hazardous waste with other hazardous waste or non-hazardous waste is not permitted
- The course of collection, transport and temporary storage, waste must be properly packed and labeled
- Transferred HW shall be accompanied by identification
- The competent authorities shall draw up their general waste management (WM) plans, and shall make these plans public
- These plans shall be compared, and made available to the competent authorities of the Member States who asks for it
- In cases of emergency or grave danger, Member States shall take all necessary steps to ensure that hazardous waste is dealt properly and not to constitute a threat to the population or the environment. [4]

Figure 2 illustrates a summary of the definition and the decision sequence to be followed. In order to be classified as hazardous waste, a waste must:

- appear on the hazardous waste list or be prescribed under section 4(2)(a)(ii) of the Waste Management Act; and also
- display one or more of the properties indicated in the Second Schedule to the Act. [5]

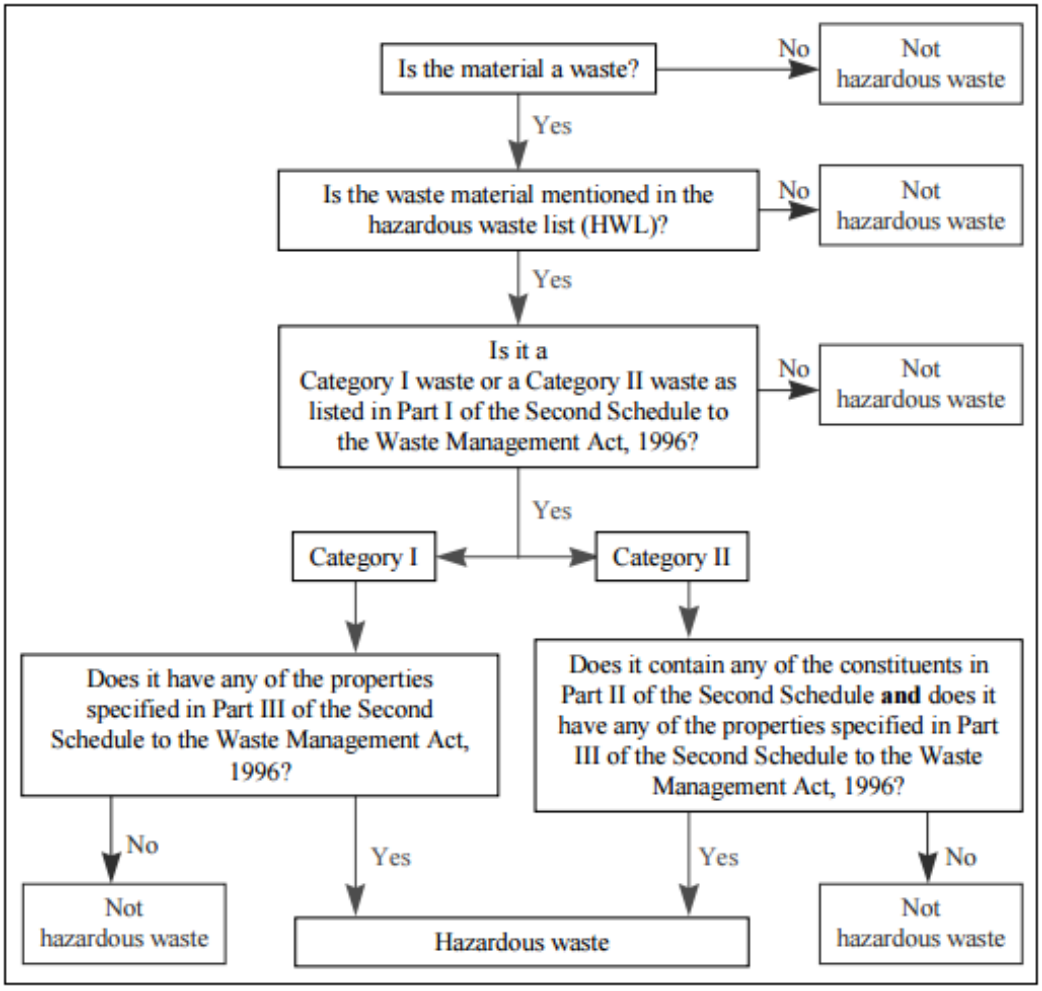

Figure 2: Hazardous Waste flowchart [6]

The list of waste which is classified as HW is based on two EU Directives:

- The European List of Waste (Commission Decision 2000/532/EC) and
- Annex III to Directive 2008/98/EC. [7]

The List of Waste (LoW) is a harmonized list of waste that is periodically reviewed and if necessary revised in accordance with Article 18 of Directive 75/442/EEC.

For better understanding six-digit codes has been given to the waste to ease the task of classifying waste and HW. For better understanding the legislation associated with the classification of waste and HW. [8]

In Basel Convention the definition of hazardous waste is based on the same principles as the EU definition, but it is referring to the national legislation. The hazardous waste definition in the OECD/Eurostat Joint Questionnaire refers to the Basel Convention definition.
The Waste Framework Directive (WFD) sets specific provisions on hazardous waste management that have to be implemented into national legislation and need to be enforced in practice. [9]

In addition to EU HWD the Waste Oils Directive 75/439/EEC has been worked out to define waste oil (WO) handling. [10]

WO is also governed by the WFD, stipulating that Member States shall take the necessary measures to ensure that

- waste oils are collected separately, when it is technically feasible;
- waste oils are treated in accordance with Articles 4 (waste hierarchy) and 13 (protection of the environment and human health);
- when it is technically feasible and economically viable, waste oils of different characteristics are not mixed and waste oils are not mixed with other kinds of waste or substances, if such mixing impedes their treatment. [11]

2.2. Hazardous Waste legislations in Estonia

The EU WFD has been transposed into Estonian legislation though the Waste Act and subordinated regulations. [12]

In addition to previously mentioned legal Acts there is a great list of regulations of which are related to generation, handling and utilization of HW in Estonia. These regulations and implementation measures are discussed below.

In Estonia HW are regulated by Waste Act. This is an Act that provides the general requirements of preventing waste generation and the health and environmental hazards arising therefrom, for organizing WM with the objective to reduce the harmfulness and quantity of waste, and liability for violation of the established requirements. [13]

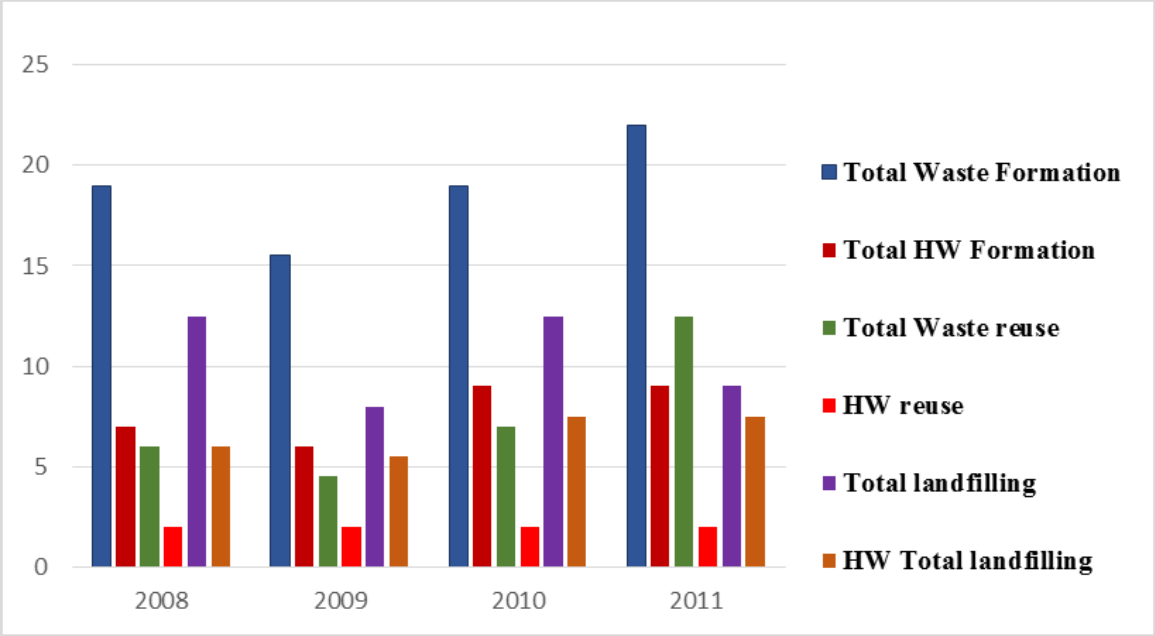

Figure 3: Total Waste Formation, reuse and landfilling 2008-2011 millions of tons per year [14]

In 2011 about 9 million tons of HW was generated, approximately 2 million tons of total amount was reused and remaining HW was landfilled. The percentage of reused HW generated has been remaining on the same level since 2008-2011.

In addition to Waste Act Estonian government has a National Waste Management Plan since 2008. It is targeted at the further organizations of WM following the principles of sustainable production and consumption. The plan is looked over and new targets are set every five years. According to Estonian National Waste Plan 2008-2013 and 2014-2020 the main aim is to achieve a decoupling between environmental pressure and economic growth. Regarding hazardous waste management, the strategy is to reduce harmfulness of waste by improving handling possibilities.

As mentioned above another measure to control and prevent illegal transport, handling and depositing of different types of waste put requirement for handling companies to have the waste permit according to the Waste Act. At the national level, the Environmental Agency is

an accredited body to provide an integrated environmental permit, waste permits, HW handling licenses and waste disposal certificates. [15]

The HW handling license is proof of relevant competence and suitability of the technology used by a company which gives the company the right to handle HW generated and delivered by other person. In business/industrial level waste permit, waste handling license and HW handling or integrated environmental permit is needed. [16]

In Estonia bigger waste generating companies usually have their own WM systems. On national level Estonia has three HW collecting stations and several private sector collection stations to support the collection network. According to Estonia Waste Management Plan 2014-2020 there were all together 7 hazardous waste collecting landfills in 2013. Part of the Plan was to re-organize all the landfills in the country and close the ones that didn't meet the requirements.

The Estonian reporting system is high level electronic reporting with full description of waste shipments and LoW codes that are linked and transformed automatically to Eurostat codes − is considered as providing highly reliable datasets. Hazardous waste generation and treatment data match quite well, also for national statistic. [17]

The European Commission "Support to Member States in improving hazardous waste management based on assessment of Member States performance" report covers the key features of requirements from the WFD that are implemented in national law:

− Estonian classification system follows the List of Waste coding system

− Labelling is well implemented;

− As regards record keeping: There are three reporting instruments: The waste reporting system (WDMS) is part of the Environmental Register and is the management system for data from waste reports. In addition, there is an Environmental Permit Information, Consignment Note Database and an annual report database.

− Permits are granted by the Environmental Board. There are two types of permit - permit for hazardous waste management ('license') and standard environmental permit.

− The mixing of hazardous waste with other hazardous waste or any other substances or materials is permitted best available technology (BAT) is used.

− Collection companies have to be authorized by public authorities and need to have a responsible person for waste handling, who has to prove expertise and knowledge on hazardous waste handling.

− During inspection, storage containers and packaging, as well as correct labelling (not only before transportation) are checked;

− Inspections are based on an inspection plan based on risk analysis. Usually, annual inspections are performed. [18]

2.3. Methods of hazardous waste disposal

AS Norma is a manufacturing company which provides compounds and seat belt assemblies to automotive industry. Processes that are used are stamping, plastic injection molding, hardening, electroplating and assembling of compounds.

Generation of HW in AS Norma:

- Surface treatment sludge are generated in surface treatment processes where electroplating waste products are Cr, Zn and Ni substances.
- Quenching salt waste are generated during metal quenching. Salts are collected within machinery preventive maintenance. Substances collected are KNO_3 as solid waste and $NaNO_2$ as aqueous solution.
- Washing liquids are mainly surfactant detergents and the mineral oil-containing aqueous solution. This waste is generated after metal processing step when stamped compound are washed before sent to subsequent processes.
- Waste oil is generated during metal and plastics processing. Oil is collected during maintenance of machinery.
- Filter materials are mainly connected with machinery maintenance containing heavy metals such as Ni, Cr, Zn and Co.

- As the company's main field is metal processing, then steel scrap is generated mainly in every process step.

Therefore research has been done to find out possible environmental friendly waste treatment methodologies used in other countries.

2.3.1. Surface treatment Sludge

According to the integrated environmental permit AS Norma is permitted to give up to 255 tons of sludge per year to waste handling companies.

Solid wastes from surface treatment contain Ni, Zn, and Cr heavy metals. Hence these waste materials which are causing serious environmental problems, can act as potential source for heavy metals. In this sense these industrial wastes can act as artificial ores. The valuable metals can be recovered from these industrial wastes. There are varieties of methods in use for recovery of heavy metals. These include pyro metallurgical, hydrometallurgical and bio-hydrometallurgical methods.

- Pyro metallurgical recovery consists of the thermal treatment of ores and metal containing wastes to bring about physical and chemical transformations. This enables recovery of valuable metals. Calcining, roasting, smelting and refining are the pyro metallurgical processes used for metal recovery. [19]

- The hydrometallurgical recovery uses mainly the leaching process. It involves the use of aqueous solutions containing lixiviates which is brought into contact with a material containing a valuable metal. Further the metals are concentrated and purified by using precipitation, cementation, solvent extraction and ion exchange. The metals are finally recovered in pure form by using electrolysis and precipitation methods. [20].

- Bio hydrometallurgy is one of the most promising and revolutionary biotechnologies. This technique exploits microbiological processes for recovery of heavy metal ions. [21]

  In last few decades the concept of microbiological leaching has played a great role to recover valuable metals from various sulfide minerals or low grade ores. Now the microbiological leaching process has been shifted for its application to recover valuable metals from the different industrial wastes. [22]

2.3.2. Salt waste from hardening processes (KNO3)

Molten salts have been used for more than 60 years for quenching. Most of the salts utilized in quenching are nitrate-based. The nitrate-based salts are binary or tertiary mixtures of sodium and potassium nitrate and nitrite.

In AS Norma salt waste from hardening are divided to two. According to the integrated environmental permit AS Norma is permitted to give up to 60 tons of salt waste per year for handling. In everyday practice approximately 50% of it is given away as solid waste and another half as wash water.

2.3.3. NaNO2 Wash water

Salt from wash water can be recovered by evaporation of its water content. This results as molten salt that is then transferred into box-type metal containers, where it is allowed to freeze into blocks. When salt addition is needed, the entire blocks or their broken-up chunks are added into the bath. [23]

Following the recovery and re use route eliminates disposal of wash water. The drawback is that it causes build-up of undesirable contaminants. Periodic adjustment of salt chemistry is required to maintain uniform quenching performance. This explains why many heat treaters prefer to dispose of their wash water. [24]

Although nitrate-based quenching salt is relatively nontoxic and nonflammable, it is classified as a hazardous material due to its oxidizing nature. When salt is contained in wash water, the hazard is reduced considerably. And many local waste treatment authorities permit discharge of wash water into their drainage system. If permission cannot be obtained, the handling of wash water can be delegated to a waste disposal company. Sludge can be used for chemical landfill, where permitted. Otherwise, it can be dissolved in water and treated the same way as the wash wash water. [25]

2.3.4. Washing liquids

The production of surfactant aqueous solutions last year in AS Norma was 60, 5 tons. For degreasing processes three washing machines are used.

Most of detergent products reach the environment with domestic and industrial wastewaters (WW). Detergent effluents can cause significant environmental problems because detergent product and its ingredients can be relatively toxic to aquatic life. [26]

Surfactants are widely used in many of the processes, such as in degreasing, in wetting surfaces and assisting other processes such as etching, and as brighteners by promoting finely divided metal deposition. Some surfactants have low degradability in aquatic systems, and the byproducts of degradation may have adverse effects. [27]

Such WW coming from industries is collected separately and given to waste handling companies. Hazardous WW must be cleaned from toxic substances before released to common treatment in WW treatment plants.

2.3.5. Waste oil

Referring to UNEP „Basel Convention on the Control of Transboundary Movements on Hazardous Waste and Their Disposal“ guidelines No. 5 the used or waste oil in the context of these guidelines means any semi-solid or liquid used products consisting totally or partially of mineral oil or synthesized hydrocarbons, oily residues from tanks and emulsions arising from industrial sources where they have been used for lubricating, hydraulic, heat transfer, electrical insulating or other purposes and whose original characteristics have changed during use thereby rendering them unsuitable for further use for the purpose for which they were originally intended.

In 2015 according to AS Norma integrated environmental waste permit 26, 7 tons of WO was allowed to be hand over to waste handling companies.

The importance of used oil consists in of the large quantities generated globally, their potential for direct re-use, reprocessing, reclamation and regeneration and because they may cause detrimental effects on the environment if not properly handled, treated or disposed of. The three most important aspects of used oils in this context are: contaminant content, energy value and hydrocarbon properties. [28]

- Recycling – the commonly used generic term for the reprocessing, reclaiming and regeneration (re-refining) of used oils by use of an appropriate selection of physical and chemical methods of treatment. [29]
- Reprocessing – usually involves treatment to remove insoluble contaminants and oxidation products from used oils by heating, settling, filtering, dehydrating and centrifuging, etc. Reprocessed oil is generally returned to its original use. [30]
- Reclamation – involves treatment to separate solids and water from a variety of used oils. Reclamated oil is usually used as a fuel or fuel extender. [31]
- Regeneration – involves the production of base oils from used oils as a result of processes which remove contaminants, oxidation products and additives I.E re-refining involving the production of base oils for the manufacture of lubricant products. [32]

According to United Nations Environmental Program there are basically only two alternatives for the destruction and disposal of waste oils in Europe:

- Re-refilling to produce lubricating base oils
- Burning as fuel

Still with increasing prices of raw material recycling of waste oils has become an economically attractive proposition. [33]

In some developed countries up to 50% of the countries' needs for lubricating oil is met through recycled oils. It has been established that almost 85% to 90% of the dehydrated Waste Oils can be converted in to useful products, be they the Base Oils for further processing in to lubricating oils or as fuel. [34]

2.3.6. Filter materials

In AS Norma filter materials for ventilation equipment are used. Average 12 tons per year. Filters are use all over the company to provide clear air and good environmental conditions for worker throw-out the year. Also PP filter cartridges, filter paper and activated carbon is used to collect Ni, Zn and Cr salt. In addition oil contaminated paper, rags and cleaning materials are collected from production and given away as filter materials.

Active carbon consists mainly of carbon with a porous structure. The pores are like a sponge connected with each other and creating a huge inner surface. This is used for the adsorption of pollutants from gas, air or liquids. [35]

The active carbon differs in two types – extruded and granulated forms. Extruded carbon is used in the gas or air processes. In the water or liquid processes the granulated carbon is used. Used carbon can be reactivated even when saturated, usually for several times and still be re-used. During reactivation the pollutants will be removed and the pores cleaned. The active carbon regains its activity and can be used again. [36]

In many cases after an activated carbon's adsorptive capacity has been exhausted it is a good practice to return it back to the Production Company for thermal reactivation. [37]

With high temperature reactivation followed by off-gas treatment, the adsorbed organic compounds are destroyed and reactivated carbon can be safely and cost-effectively recycled back to facilities for continued use. A number of important steps are involved in the reactivation process:

- Spent activated carbon is heated in furnaces devoid of oxygen using steam as a selective oxidant.
- Adsorbed organics are either volatilized from the activated carbon or pyrolysis to a carbon char.
- Volatilized organics are destroyed in the furnace's afterburner.
- Acid gases are removed by means of a chemical scrubber.
- The high-temperature reaction with steam serves to restore the adsorptive capacity of the activated carbon. [38]

Through reactivation, the spent granular activated carbon can be recycled for reuse, virtually eliminating the costs and long-term liability associated with disposal. [39]

A significant benefit of reactivation and recycling is that the CO2 footprint associated with reactivation is significantly lower than that associated with the production, supply and use of virgin activated carbon. [40]

2.3.7. Steel scrap

AS Norma main field is metal processing so the steel scrap is generated mainly in every process step. As given in integrated environmental waste permit in 2015 company was allowed to give 7500 tons of steel scrap to handling companies.

According to The European steel association the steel scrapped and gathered all over the Europe is mainly recycled. It is known that steel itself is 100% recyclable and it owns a great value. It is been said that it can be the most valuable raw material for steel production. It can be reused over and over again without any loss of quality. [41]

There is and well-established market for the steel scrap because of its value. There are two process routes that rely on steel scrap in different ways. Steel production via blast furnaces is based on iron ore and uses scrap as an additional element when the iron from blast furnace is refined to steel in a basic oxygen converter. And the other line is Steel production in electric arc furnaces what is almost completely based on scrap. [42]

EUROFER states that this is not only highly resource-efficient but it also reduces the overall environmental footprint of steel making considerably. The two process routes show CO2 emissions from steel production decreasing with every recycling cycle. All steel scrap returned to European steelmakers is recycled, but demand for new steel products exceeds the amount of scrap available. At present, about 50 per cent of the total EU steel production is derived from recycled steel scrap. [43]

It is brought out that increasing steel scrap use offers large economic and societal benefit for the EU as a whole. EAF using scrap is perfectly suitable for all steel qualities with the exception of some deep drawing steel qualities for automotive exposed parts. The key features are listed below:

- Steel scrap use allows a large reduction in energy consumption, CO2 emission and virgin material usage.
- Steel scrap EAFs are much more capital efficient, leading to lower maintenance costs.
- Steel scrap EAFs are more productive and employ a smaller workforce per plant, particularly in difficult or dangerous jobs.
- Steel scrap EAFs are much more financially resilient. [44]

3. Methodology

3.1. Indicators

A list of companies discussed can provide HW handling services and a selection will be made. The goal of the pre selection is to bring out three most competitive companies that can provide the best needed services for AS Norma. Pre evaluation is made based on location, tendency and collectable wastes. In this thesis three main aspects are valued when choosing suitable solution:

- Location
- Environmental views of service providers
- Complex services – waste licenses, transportation, containers
- Additional values – ISO certificates, innovative solutions

3.2. Description of companies qualified in Estonia

In Estonia there are seven companies that can be suitable for HW. Table 1 below gives a primary overview for the pre selection of most suitable companies on the market. There are companies dealing with final treatment of the waste and also companies who only collect, sort and resell the wastes. In the table availability of ISO certificates, location of the company, tendency and handled waste types have been listed. It should be mentioned that for waste oil (WO) burning in Estonia Kunda Nordic Tsement AS and Maxit Estonia AS are licensed however they are not suitable cooperation partners for AS Norma because they do not deal with collecting of WO.

Only large service providers presented in Table 1 and small or niche companies have not been considered in the current work. Dealing with several niche companies for every waste type will be time consuming and add extra costs.

Table 1: Comparison of HW service providers in Estonia.

Company	ISO	Location	Tendency	Waste code
BAO ohtlikud jäätmed OÜ	-	Tallinn	Municipality Companies	*Waste generated during surface treatment of metal or other materials *Ferrous metal filings and turnings *Mineral oil-based non-chlorinated engine, gear and lubricating oils *Other emulsions *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing
EcoPro AS	9001 14001	Tallinn Kiviõli Vaivara	Municipality Companies	*Waste generated during surface treatment of metal or other materials *Sludge and solids from tempering processes *Ferrous metal filings and turnings *Mineral oil-based non-chlorinated engine, gear and lubricating oils *Other emulsions *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing
Ekoservis Teenused OÜ	-	Tallinn	Municipality Companies	*Waste generated during surface treatment of metal or other materials *Ferrous metal filings and turnings *Mineral oil-based non-chlorinated engine, gear and lubricating oils *Other emulsions *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing
Hiiu Autotrans OÜ	-	Kärdla	Municipality Companies	*Mineral oil-based non-chlorinated engine, gear and lubricating oils *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing
Kesto OÜ	-	Tallinn	Municipality	*Waste generated during surface treatment of metal or other materials *Ferrous metal filings and turnings *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing
Ragn-Sells AS	9001 14001	Tallinn Vändra Tamsalu Saku Pääsküla Pärnu-Jaagupi Tartu	Municipality Companies	*Waste generated during surface treatment of metal or other materials *Sludge and solids from tempering processes *Mineral oil-based non-chlorinated engine, gear and lubricating oils *Other emulsions *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing
Veolia Keskkonnateenused AS	9001 14001 18001	Tallinn Tartu Viljandi	Municipality	*Mineral oil-based non-chlorinated engine, gear and lubricating oils *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing

Epler & Lorenz AS	9001 14001	Tallinn Tartu	Municipality Companies	*Waste generated during surface treatment of metal or other materials *Sludge and solids from tempering processes *Ferrous metal filings and turnings *Mineral oil-based non-chlorinated engine, gear and lubricating oils Other emulsions *Other emulsions *Dangerous substances, contaminated with absorbents, wiping cloths, filter materials and protective clothing
High Tech Recycling OÜ	-	Nissi parish	Companies	*Mineral oil-based non-chlorinated engine, gear and lubricating oils Other emulsions
PORTLIF GRUPP OÜ	-	Kiikla parish	Companies	*Mineral oil-based non-chlorinated engine, gear and lubricating oils Other emulsions *Other emulsions

Table 1 indicates that only two companies - EcoPro AS and Epler & Lorenz AS has all needed licenses for all six HW types and is capable of providing full HW handling service. If steel scrap is considered separately because these wastes can be given away for free or even be paid for, then also Ragn-Sells AS is suitable service provider.

Both EcoPro AS and Ragn-Sells AS are business customer oriented companies and have ISO 9001 and 14001 certificates giving them additional value. As AS Norma locates in Tallinn therefore it is logistically more suitable to use companies that have their waste collection station nearby. This will also reduce transport costs during collection and transportation of waste, also it is more likely that service provider can act quicker when waste service is needed.

Epler & Lorenz AS can be mostly compared to EcoPro AS services. All waste types are covered and company is providing final treatment for WO. Epler & Lorenz AS is located in Tallinn, is ISO 9001 and 14001 certificated and are business customer oriented company.

BAO Ohtlikud jäätmed OÜ and Ekoservis Teenused OÜ can also provide all services accept Salt waste from tempering process collection. When choosing these companies still additional company is needed. In comparison with previously mentioned both companies also located in Tallinn and are business customer oriented but do not have ISO certifications.

As Kesto OÜ and Veolia Keskkonnateenused OÜ are municipality oriented companies and they are not providing services to private businesses so they cannot be considered as suitable co-operation partners for AS Norma.

To specify High Tech Recycling OÜ deals with WO collecting and final treatment. Portlif Grupp OÜ additionally for WO is licensed to handle washing liquids. These companies are rather niche companies and can be considered as WO handling service co-operation. As they are more niche companies then they are not considered as potential co-operational partners to AS Norma in this thesis.

As steel scrap has a market value and the amount of produced steel scrap is large it is financially more profitable to sell the waste to steel oriented companies. If previously mentioned HW handling companies can also own respective license, the steel scrap is usually collected for free or with low cost. When sold to steel oriented companies reasonable price is paid for the steel and some profit can be made for AS Norma.

For that reason, Table 2 is composed of possible co-operational partner for steel scrap handling and treatment providers.

Table 2: Comparison of Steel scrap handling service and treatment providers.

Company	ISO	Location	Tendency
Kuusakoski AS	14001	Tallinn, Rakvere Jõhvi, Narva Paide, Rapla Paldiski, Tartu Viljandi, Pärnu Võru	Municipality Companies
BLRT Refonda Baltic OÜ	-	Tallinn, Tartu Rakvere, Pärnu Türi, Kohtla-Järve Võru, Narva	Municipality Companies
Tolmet Tallinn OÜ	-	Tallinn, Narva Tartu, Pärnu Jõhvi, Valga Sillamäe, Karksi-Nuia	Municipality Companies
Tehnomarket OÜ	-	Tallinn	Municipality Companies
Alexers OÜ	-	Tallinn	Municipality Companies
Motley Grupp OÜ	-	Tallinn	Municipality Companies
Hansfer OÜ	-	Tallinn	Municipality Companies

3.3. Selection of companies

Based on analyze of table 1 three companies are selected as possible co-operational partner for AS Norma HW handling. These companies are EcoPro AS, Ragn-Sells AS and Epler & Lorenz AS. All three companies will be shortly described below. Additionally, price offers are asked from the companies. To get most precise prices AS Norma quantities of waste and needed substance content was sent. To ensure accuracy of prices the information provided to the companies is based on AS Norma 2015 integrated environment permit.

EcoPro AS

EcoPro AS is Estonian company located in Tallinn. It has been dealing with HW since 1992. Company has managed since 1993 to 2009 most of the national HW depots. In addition to direct work EcoPro AS has exercised the area of environmental pollution studies, environmental assessments, and also research papers.

Company holds quality and environmental management certificate, has three HW handling centers and is business customer and local municipality oriented company. EcoPro AS brings out their main objectives of the management system that are: to identify customers wishes and expectations and their exact fulfillment accordance to established standards and customers' expectations.

Addition to HW handling company provides several other services like environmental assessments, pollution studies and environmental training and consultancy.

EcoPro AS management policy establishes requirements to:

- prevent and eliminate non-compliant waste management service;
- use all resources sparingly;
- use the best available technology for waste treatment;
- to prefer a contractual relationship with a qualified and informed subcontractors and suppliers;
- to provide the necessary staff training and continuous improvement of skill.[45]

At the moment EcoPro AS is the main service provider to AS Norma. Main reason for that is that the company has all needed licenses to deal with all HW.

Ragn-Sells AS

From Ragn-Sells AS I had chance to have a conversation with Olav Ojala who works as a Special Waste service manager.

Ragn-Sells AS itself does not own waste treatment plants (WTP) in Estonia. The company is mainly engaged in waste collection and sorting, which later resold. Company itself origins of the Swedish Group company established 135 years ago.

Co-operation agreements are group-based, allowing smaller separately collected waste to be added to the other group collected waste. Such cooperation allows rapid discarding of waste, because the needed volume for processing will be collected quicker.

The company's main objective in the field of HW is to recover waste as much as possible. Ragn-Sells AS develops its services in accordance with the circular economy principles. Circular economy is central to the sustainable use of natural resources. Circular economy model where waste is separated by natural materials and synthetic materials. It creates good preconditions, that they can be reused. When the materials are mixed together during the production process, it is almost impossible to re-allocate them later, and therefore the majority of waste going to landfill or incineration.

Local HW collection and sorting takes place in Estonia. One part of the HW is exported, because there is no possibility for recovery in Estonia for example WO. Approximately 90% of recovered oil is exported in Germany at a refinery plant. The rest, which cannot be sent to refining will be sold to Kunda Cement factory and will be burned. Other chemicals are collected separately and sold to different niche businesses within Estonia.

Ragn-Sells AS holds approximately 30% of market share in customer-oriented solutions in Estonia. The main advantages are the nationwide network that ensures rapid logistical solutions that ensure flexibility towards customer needs and large industrial park ensuring timely service and close cooperation between the client manager and client leads to the best solutions.

Comprehensive customer solution development is what Olav Ojala brings out as a high added value. In addition to consulting services Ragn-Sells AS offers a new development trend: to offer preventive solutions development service for preventing or reducing the total waste generation on client sites.

In addition, Ragn-Sells AS has ISO 9001 and ISO 14001 certificates, and has been acknowledge with several awards. A long history and 23 years of experience in Estonian market makes Ragn-Sells AS a trustworthy company.

At the moment Ragn-Sells AS is the second service provider to AS Norma. Main reason for that is that the company has all needed licenses to deal with all HW.

Epler & Lorenz AS

Epler & Lorenz AS is Estonian company located in Tallinn and Tartu. Company started operating in 1991 with WO collecting and burning. Owning a first oil incinerator built in Baltic countries. It soon expanded its activities to include other types of waste. Now it is considered to be one of the biggest WH companies in South Estonia.

As mentioned previously company has waste incineration capacity of 1,620 t/year and an average of 225 kg/hour. While at the same time it is possible to burn waste in three different states. [46]

Company's goals are to reduce the amount of waste going to landfills by developing waste recycling and contributing to the conservation of surrounding environment. Guided in its activities by the following principles:

- waste recovery promotion;
- economic use of resources;
- waste generation reduction;
- reduction of environmental pollution. [47]

It holds quality and environmental management certificate and is business customer and local municipality oriented company. In addition, company provides soil purification and separation

from contamination of HW substances, liquidation of emergencies and fuel tanks cleaning. [48]

Since 2007 Epler & Lorenz AS is operator of South Estonian HW collecting center. About 90 per cent of collected wastes are recycled.

3.4. Data collection

3.4.1. Interviews with relevant stakeholders

The first step in this process was to identify relevant stakeholders. Personal interviews, by telephone or by e-mail have been conducted with the stakeholders identified. The aims of the interviews were to collect more information, to assess the quality of already collected information (via desk research, summarized in the draft factsheet). Also to obtain additional information about soft values of the company – environmental approach and services.

The interviews were not formally structured, but lead by the demand for data and information in the given case.

The purpose of the study was also to present the different principals of HW management in handling companies, including those of:

- **Economic model used;** the main values, which resist on;
- **Technological solutions;** landfilling, recycling, export;
- **Complex solutions;** services provided, prevention methods, new innovations;

3.4.2. Desk research

The expert interviews have been complemented by further desk research, provided by the interviewed experts or collected via additional search (official websites, guidance, etc.). The desk search included:

- Follow-up on information collected during screening phase (i.e. criteria with discrepancies) literature, further studies on hazardous waste (e.g. major hazardous waste streams, amounts, treatment applied, and reports) and statistical data if available.

- Identification of data and information gaps focusing on 1) waste generation and treatment in the country and 2) obligation/practice of HW collection and storage.
- The primary sources for the desk research include websites and data basis from administrative bodies, statistical offices and public reports.

3.5. Cost Benefit Analysis

A Cost Benefit Analysis (CBA) is an economical assessment method and a systematic approach that quantifies the value of outcomes, to estimating the strengths and weaknesses of alternatives that satisfy transactions, activities or functional requirements where the costs and benefits of one or several specific activities or projects are assessed. In other words, CBA is a decision-guiding tool that helps to determine the feasibility of a project economically. CBA can be used to guide several types of decisions. It is appropriate to use either for a yes/no decision for a single activity to decide if it will be undertaken or making choice between two or more different activities.

Broadly the CBA has two purposes:

- To determine if it is a sound decision and
- To provide a basis for comparing projects - comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.

To comprehensively conduct a CBA, an analytical framework is used. It enables that extensive overview during the CBA is well managed. Originally a nine-step analytical framework, however in this thesis only six-step is used. Table 3 illustrates these steps.

Table 3: Analytical Framework for CBA (modified).

Analytical framework for CBA	
1	Identify alternatives and Base Case
2	Identify cost and benefits
3	Discount future cost and benefits
4	Calculate the decision criteria
5	Sensitivity analyze
6	Identify preferred options/ give recommendations

The CBA Analytical Framework has been modified in the lights of the goals of this thesis. Analyze will be conducted through the six-steps.

3.5.1. Identifying alternatives and Base Case scenario

As a first step of CBA, the project alternatives and base case should be precisely specified. It is important to have a well-advised number of alternatives against base case scenario owing to the fact that it gets difficult to have a detailed evaluation within several courses of actions. [49]

In this thesis, two different alternatives and base case scenario will be discussed. As it is seen in table 4, three companies are chosen for further analyze. All chosen alternatives are HW handling permit owning companies that are capable of handling previously mentioned wastes.

Table 4: Identification of alternatives and Base Case scenario

Base Case and Alternatives	
Base Case	EcoPro AS is used as a service provider for HW handling in Norma AS
Alternative 1	Ragn-Sells AS and EcoPro AS
Alternative 2	Epler & Lorenz AS

These two alternatives and base case scenario are compared to each other to decide economically better course of action for the AS Norma.

3.5.2. Specification of Alternatives and Base Case scenario

As a first step of CBA, the base case scenario and alternatives will be specified. It is important to have a well-advised number of alternatives against base case scenario owing to the fact that it gets difficult to have a detailed evaluation within several courses of actions [50].

In this thesis, two different alternatives and base case scenario will be discussed. As it is seen in table 4, first alternative is combination of Ragn-Sells AS who provides HW service by collecting and sorting waste and EcoPro AS. No treatment will be provided by Ragn-Sells. All waste will be sold or sent out to other countries for treatment. The other alternative is Epler & Lorenz who also collects waste but has possibilities to treat the waste in Estonia. Company uses incinerations to burn waste and produce energy. More precise description of the companies' are given in section 3.2. Shortly, these companies licensed and have authorization to deal with previously mentioned HW.

Table 5: Identification of project alternatives and Base Case scenario

Base Case	Alternative 1	Alternative 2
Best prices for every waste type; One handling company; Prices fixed by contract; Geographical location – smaller transportation costs; Separate handling.	Nationwide network; Rapid logistical solutions; Flexibility towards customer needs; Large industrial park - timely service; Close cooperation between the client manager and client; Geographical location – smaller transportation costs. Separate handling.	Oil incinerator One of the biggest WH companies in South Estonia. Waste incineration capacity of 1,620 t/year and an average of 225 kg/hour. Possible to burn waste in three different states. Operator of South Estonian HW collecting center Separate handling.

3.5.3. Identification of cost and benefits

In this section the explanation of costs and benefits of each alternative are provided. Possible costs and benefits are discussed for two alternatives.

Base Case

The Base Case scenario describes the situation when different wastes are given to EcoPro AS WHC based on prices given to every waste type separately. Main costs are handling costs but additionally extra cost for transportation and/or packaging rental for several waste types are not included in base case cost table. The costs are calculated based on given price and waste amount given in AS Norma by integrated environmental permit.

As it is known Steel scrap when collected separately from other waste are reusable resources and can be given to waste handling companies for free of charge or can be sold for profit. That's why in this cost table it is marked as zero cost wastes and it will be discussed separately. All waste types, costs and benefits are presented in table 6 for base case scenario and two alternatives.

Table 6: Hazardous waste, cost and benefits.

Base Case	Waste type	Cost [€/y]
	Surface treatment sludge	33915 €
	Salt waste from tempering process	9588 €
	Washing liquids	5608 €
	Waste Oil	938 €
	Filter materials	2300 €
	Steel scrap	0 €
Alternative 1	Surface treatment sludge	-
	Salt waste from tempering process	-
	Washing liquids	-
	Waste Oil	0 €
	Filter materials	0 €
	Steel scrap	0 €
Alternative 2	Surface treatment sludge	66 300€
	Salt waste from tempering process	22 800€
	Washing liquids	13 310€
	Waste Oil	0 €
	Filter materials	2640 €
	Steel scrap	0 €

Ragn-Sells AS

The alternative 1 is to give HW to Ragn-Sells AS. When information was gathered it was shown that company has all license needed for AS Norma HW handling. For addition price offers was asked from the company and amount of waste according to integrated environmental permit was given. Also to specify exact waste substance content was provided to get as precise price offer as possible.

Unfortunately the amounts of waste generated and specificity of waste company was not able to provide solutions for all waste handling. Offered services and prices presented in table 6. For price offer additional costs like transportation and/or packaging rental for several waste types are not included in Ragn-Sells AS cost table. In CBA combination of Ragn-Sells AS and EcoPro AS prices will be calculated.

Compared to base case scenario, there is a possibility to sell the WO or at least give it away for free. If different WO types collected separately the selling price calculated could be up to 1869 €/y. This will reduce the cost for WO handling or even can be financially profitable. In other hand company can be used only with combination with others service providers as Ragn-Sells AS does not offer all services.

Epler & Lorenz

The alternative 2 is to use Epler & Lorenz AS as WH cooperation partner. The company has all license need for AS Norma HW handling. Price offers were asked from the company and amount of waste according to integrated environmental permit was given. Also to specify exact waste substance content was provided.

Offered services and prices presented in table 6. For price offer additional costs like transportation and/or packaging rental for several waste types are not included.

Compared to base case scenario and similar to alternative 1 there is a possibility to give WO away for free. This will reduce the cost for WO handling and in that side can even be financially profitable. Similar to base case scenario the company offers a complex solution – all waste types can be given to one service provider.

Comparing prices even when WO is earning profit the overall solution is more costly than base case. In comparison with alternative 1 the filter material prices is lower even when repayment from WO is gain.

3.6. Identifying alternatives and Base Case scenario of Steel Scrap

AS Norma provides steel scrap that at the moment is sold to three service providers. Steel scrap is separated by type: Industrial metal waste, Heavy melting steel (HMS 1) and Heavy melting steel with galvanized and blackened steel (HMS 2). After collection material is sold separately to different service providers.

In this case the pre selection is made by company size. As AS Norma has large quantities of steel scrap to handle. Only waste handling company (WHC) with the main field of buying, processing and selling ferrous- and nonferrous scrap metal will be considered. As shown in previous section the price for steel scrap is usually zero. Also WHC that provide other services also do not usually have the capacity to handle so large amounts of steel scrap at once because they are collecting and reselling the metal not processing by themselves.

In table 7 Base Case scenario and two alternatives are presented. In AS Norma the base case is selling different metal types to different service providers. As the BLRT Refonda Baltic OÜ and Kuusakoski OÜ are the biggest companies and they also considered to be alternative 1 and 2. Price offers based on metal type and yearly amount are taken. Alternative is chosen by price and services offered – all types of waste metal can be handled and transportation service is provided by one service provider. Altogether seven price offers were taken.

Table 7: Identification of alternatives and Base Case scenario for Steel scrap

	Base Case and Alternatives on Steel scrap
Base Case	Steel Scrap is sold to BLRT Refonda Baltic OÜ, Kuusakoski AS and Mast Europe OÜ.
Alternative 1	Kuusakoski AS
Alternative 2	BLRT Refonda Baltic OÜ

These two alternatives and base case scenario are compared to each other to decide economically better course of action for the AS Norma. Additionally environmental and social benefits for each scenario are provided.

Kuusakoski AS

Kuusakoski AS is a customer-focused, pioneering, environmentally friendly provider of recycling services with an international track record. A passion for the deeper understanding of materials and recycling drives Kuusakoski innovations and helps to develop more efficient recycling solutions. They strive to be unconditionally ethical and transparent in everything that they do – and this is a key that makes them a reliable partner. [51]

Companies' core business is metal recycling. Industrial process from the separated metals and other materials are sold raw material to Finland and elsewhere in the world. Thanks to recycled raw material usage in industry the ore mining and enrichment will be reduced. The recycled metal saves raw material use up to 60-95 per cent depending on the product energy. Company has minimized the amount of waste going to landfill: they are currently able to recycle or reuse up to 90% of the materials collected – and in some cases even more. [52]

Norma AS uses Kuusakoski AS as a co-operational partner. HMS 1&2 are sold to the company.

BLRT Refonda Baltic OÜ

The main activity of OÜ BLRT Refonda Baltic is buying, processing and selling ferrous- and nonferrous scrap metal. The company is aimed not only at providing the population, enterprises and government agencies a comprehensive range of services utilization of recycled materials, but also - at multilateral activities related to environmental protection and conservation of Earth's interior. In Tallinn, the scrap yards of the company are situated Kopli 103 and Betooni 7. Other (seven) scrap yards are locations all over Estonia and equipped with electronic weighing bridges and cargo handling machinery. There is a vehicle fleet of container trucks, with the possibility of loading and transportation of scrap metal. For storage and shipment of scrap metal is used the area adjacent to the seaport terminal. The scrap yard in

Tallinn is equipped with Metso Lindemann shearing press that allows to handle almost any scrap metal. [53]

Company follows a flexible financial policy while working with clients, focusing on offering high prices and the shortest terms of payment, which gives the possibility of expanding the range of companies and individuals working with OÜ BLRT Refonda Baltic. [54]

Industrial metal waste is sold to the company.

3.6.1. Specification of Alternatives and Base Case scenario of Steel Scrap

In this thesis, two different alternatives and base case scenario will be discussed. As it is seen in table 7, first alternative is Kuusakoski AS who deals with buying, processing and selling ferrous- and nonferrous scrap metal. The second alternative is BLRT Refonda Baltic OÜ who also has same possibilities to handle the steel scrap in Estonia. Company recycles up to 90 per cent of collected steel. More precise description of the companies' are given in section 3.5.1 Shortly, these companies licensed and have authorization to deal with steel scrap handling in Estonia.

Table 8: Identification of project alternatives and Base Case scenario

Base Case	Alternative 1	Alternative 2
Best prices for every steel type; Geographical location – smaller transportation costs; Separate handling.	Nationwide network; Flexibility towards customer needs; Large industrial park - timely service; Geographical location – smaller transportation costs; Transportation services Separate handling.	Nationwide network; Large industrial park - timely service; Geographical location – smaller transportation costs; Transportation services: Separate handling.

These two alternatives and base case scenario are compared to each other to decide economically better course of action for AS Norma.

3.6.2. Identification of cost and benefits

In this section the explanation of costs and benefits of each alternative are provided. Possible costs and benefits are discussed for three alternatives.

Base Case

The Base Case scenario describes the situation when different steel scrap types are given to three different handling companies. The selection is based on prices given to every steel type separately. Refunds are collected by selling but additionally extra cost for transportation and/or packaging rental are not included in base case cost table because based on the agreement with co-operational partners AS Norma will not bear any costs. As the prices are calculated after exchange price and are changing monthly then the benefits are calculated based on given monthly price and waste amount given in AS Norma by integrated environmental permit.

Table 9: Steel Scrap cost and benefits in AS Norma.

	Waste type	Costs [€/y]	Refunds [€/y]
Base Case	Industrial metal waste	0€	1 225 827 €
	HMS 1		246 726 €
	HMS 2		86 002 €
Alternative 1	Industrial metal waste	Transportation - 18 534,00 €	818 100€
	HMS 1		160 515€
	HMS 2		53 350€
Alternative 2	Industrial metal waste	Transportation - 13 534,00 € Rental - 17 401,00 €	909 000€
	HMS 1		166 460€
	HMS 2		60 625€

Kuusakoski AS

The alternative 1 is to give all the steel scrap types produced in AS Norma to Kuusakoski AS. When information was gathered it was shown that company has all license needed for AS

Norma steel scrap handling. For addition price offers was asked from the company and amount of waste according to integrated environmental permit was given. Also exact steel type and amount was provided to get as precise price offer as possible.

When handling prices were calculated only prices given by recent price were considered. Offered services and prices presented in table 9. Additional costs like transportation and/or packaging rental for several waste types are included in Kuusakoski AS cost table.

BLRT Refonda Baltic OÜ

The alternative 2 is to use BLRT Refonda Baltic OÜ as Steel Scrap handling cooperation partner. Similarly to alternative 1 all requirements where met and additional price offers where asked with specified information. Offered services and prices given are brought out in table 9. For price offer additional costs like transportation and/or packaging rental for several waste types are included in BLRT Refonda Baltic OÜ cost table.

3.7. Description of Discount Rate, NPV, IRR and BCR

The decision criterion in CBA is based on three values: Net Present Value (NPV), Internal Rate of Return (IRR) and Benefit-Cost Ratio (BCR). To determine the best option among other possibilities, each value is compared to those of other course of actions.

Net Present Value (NPV) is used to calculate the yearly benefit and cost components into a present value. It is used to compares if the sum of discounted gain is higher than that of discounted loses. In a CBA, discounting is used to convert all future costs and benefits into present-day values where the time value of money is taken into account. Time value of money - money value decreases in time. To determine NPV value the discount rate must be used. It must be known that discounting is different from inflation since the time value of money can be applied even in the lack of inflation. Higher the discount rate lower the NPV value. Main interpretation from the NPV value is that the project is profitable when the NPV > 0. When many alternatives are taken into consideration, the alternative with the highest NPV is primarily preferred [55].

A general formula for calculating the NPV is given as follow.

$$NPV = -K + \sum_{t=0}^{n} \frac{B_t - C_t}{(1 + p_x)^t}$$

In this equation:

— K refers to initial capital investment for the first year

— B and C stand for benefits and costs in year t, respectively

— px denotes the discount rate.

Secondly, the Internal Rate of Return (IRR) is a discount rate at which a project's NPV is equal to zero [56].

When IRR is greater than the discount rate, the NPV is positive which means the project is economically feasible. IRR is used to assess the attractiveness of a project. As a result, the project with highest IRR will be chosen. Also, IRR can be seen as the rate of return on the investment of a project. The formula for IRR is given as follow.

$$0 = -K + \sum_{t=0}^{n} \frac{B_t - C_t}{(1 + \pi)^t}$$

Here, π represents IRR and other symbols are described as in the NPV formula.

Benefit-Cost Ratio (BCR) is also used to decide more financially attractive project. The ratio should be larger than or equal to one which fundamentally means that the present value of the benefits should be superior to that of costs so as to have profit. The general formula is as follow.

$$BCR = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+p_x)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+p_x)^t}}$$

3.8. Limitations of the study

This study is a preliminary feasibility study where a partial CBA is used. Also, there are some considerable limitations that can have positive or negative effect on the results. Firstly, not every elements of CBA included in this study. In other words, price fluctuations of the cost and benefit source have not been analyzed. Owing to the fact that all companies were not able to make an offer for all types of waste and some price offers where preliminary and unspecified. As a result of research it has been discovered also that there are not many alternatives to consider from the point where company would like to take services from one provider and also have a competitive price. The specificity of waste and produced amount narrows possibilities in large extent. In addition, it is clear that steel scrap must be considered separately to get a profit or eliminate the extra cost.

4. Results

In this chapter the costs and benefits will be discussed both for HW and Steel Scrap handling companies. Calculations for both cases have been done and best possible solutions will be proposed and analyzed. Secondly, the key parameters of partial CBA explained in methodology part will be calculated. In lights of these parameters, the best scenario will be presented in terms of financial situation. In addition, environmental and social benefits will be discussed.

In detail partial CBA are conducted for 10 years. Costs and benefits are presented for each year. Furthermore, undiscounted and discounted flows are analyzed. The discount rate has been taken into consideration as 0.04 [56]. After that, NPV, IRR and BCR will be calculated. Finally, sensitivity analysis is composed in order to see how possible fluctuations in discount rate can influence each scenario.

4.1. Monetization and of costs and benefits with NPV and BCR of HW and Steel scrap handling

In this section, the costs and benefits that can be monetized are presented. Results are presented and analyze have been made for all scenarios proposed.

Scenario 1 as Base Case scenario

In this current scenario base case from HW and from Steel scrap are combined and calculated. For this costs for HW handling are monetized. These cost consists of treatment costs which are paid to the WHC for service. Based on contracts no cost is bared by AS Norma in connection with steel scrap handling. There are three types of monetized benefit including selling of steel scrap.

It is knowledge that there is annually 414 tons HW and 7500 tons of steel scrap that need to be handled over to the service providers yearly. As handling costs vary depending on the type of waste the average sum per ton can be calculated ca 127 €/t. For selling of steel scrap ca 208 €/t of profit will be earned. That means the annual cost of waste handling is 52 448 €/y and 1 558 555 €/y of profit. The costs per year for 10 years and total grand cost at the end of 2025 are shown in the first table [Appendix 1].

Total costs and benefits for each year should be presented to bring up net cash flow per year. In the second table, undiscounted flows are given for 10 years. But, in reality the money will lose its value with every year and these numbers should be discounted to get closer to more realistic approach [Appendix 1]. Discount factors are calculated based on discount rate of 0.04. In the result of discounting, net cash flow and cumulative are found. Undiscounted and discounted cash flows are presented in figure 4 and 5, respectively.

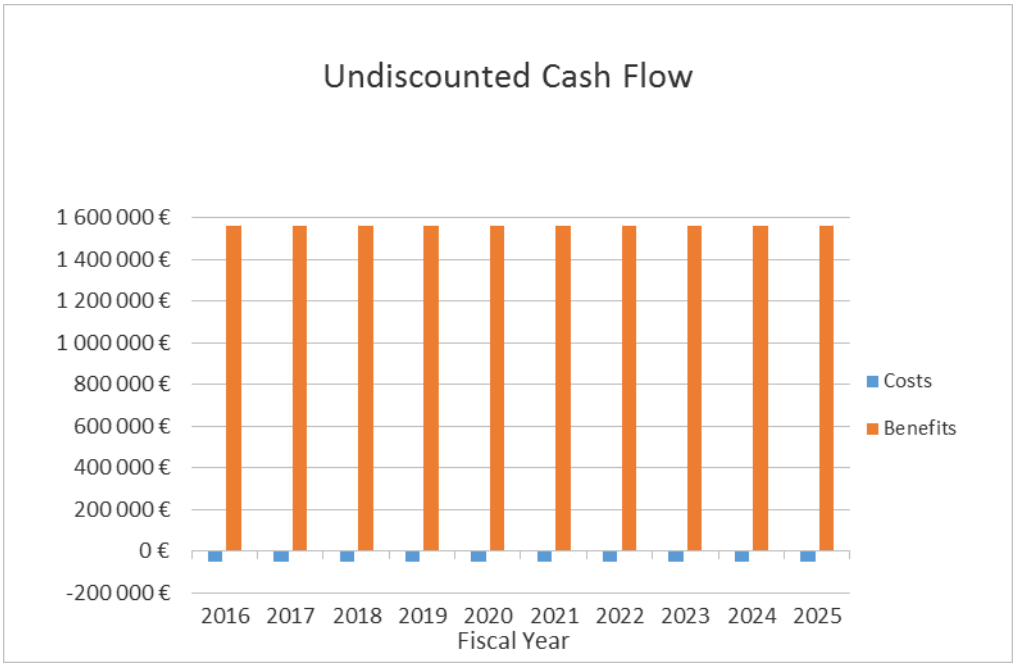

Figure 4: Undiscounted cash flows of Scenario 1

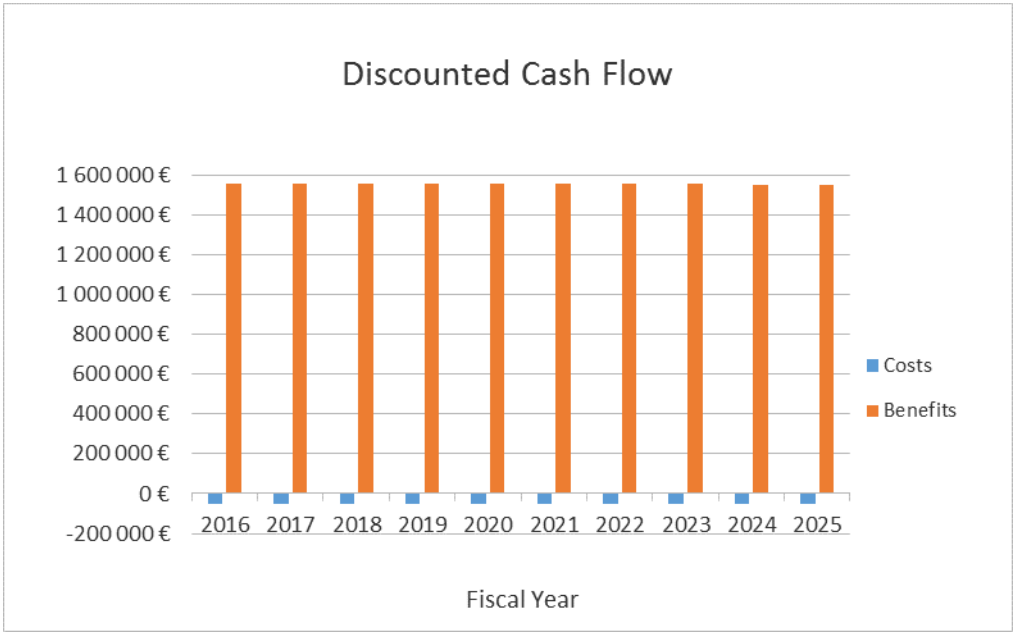

Figure 5: Discounted cash flows of Scenario 1

In figure 5 discount factor is considered in 10 years' time. The final cost will decrease 0, 1% compared to the table 4 by the year 2025 and the benefits will decrease 0, 4% by the year 2025.

As a result, Net Present Value (NPV) is found 15 034 000 EUR at the end of 2025. In base case scenario no BCR is calculated.

Scenario 2

For the scenario 2, HW alternative 1 and Steel scrap base case where combined. As the Ragn-Sells AS does not provide all services then calculations for services not provided were made based on HW base case. Also for Steel scrap three companies are used. In this scenario the actual situation of AS Norma waste handling is presented.

To calculate scenario 2 base case benefits and treatment cost from HW handling were monetized. In this scenario benefits considered are WO selling profit, Steel scrap selling profit and cost from base case as benefits. This scenario shows that there is significant change compared to base case. As, the prices vary the average sum per ton can be calculated ca 119 €/t. That means the annual cost of HW handling is 49 111 €/y. For Steel scrap average profit is

round 208 €/t. The costs per year for 10 years and total grand cost at the end of 2025 are shown in the first table [Appendix 2].

In the second table, undiscounted flows are given for 10 years. All calculations are done similarly to Base Case and are visible in [Appendix 2]. Undiscounted and discounted cash flows are presented in figure 6 and 7, respectively.

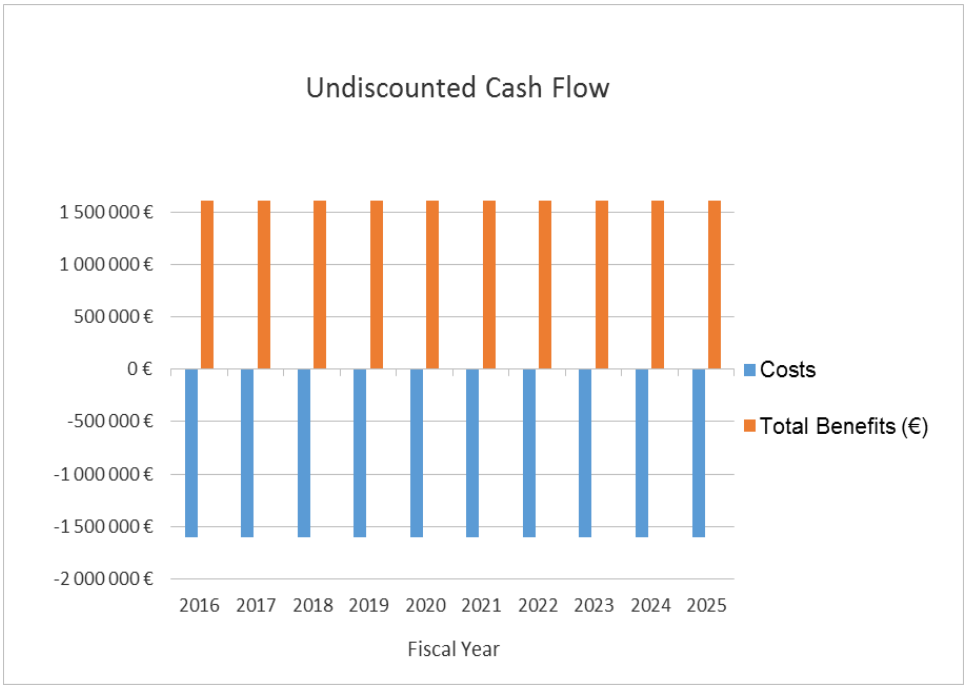

Figure 6: Undiscounted cash flows of Scenario 2

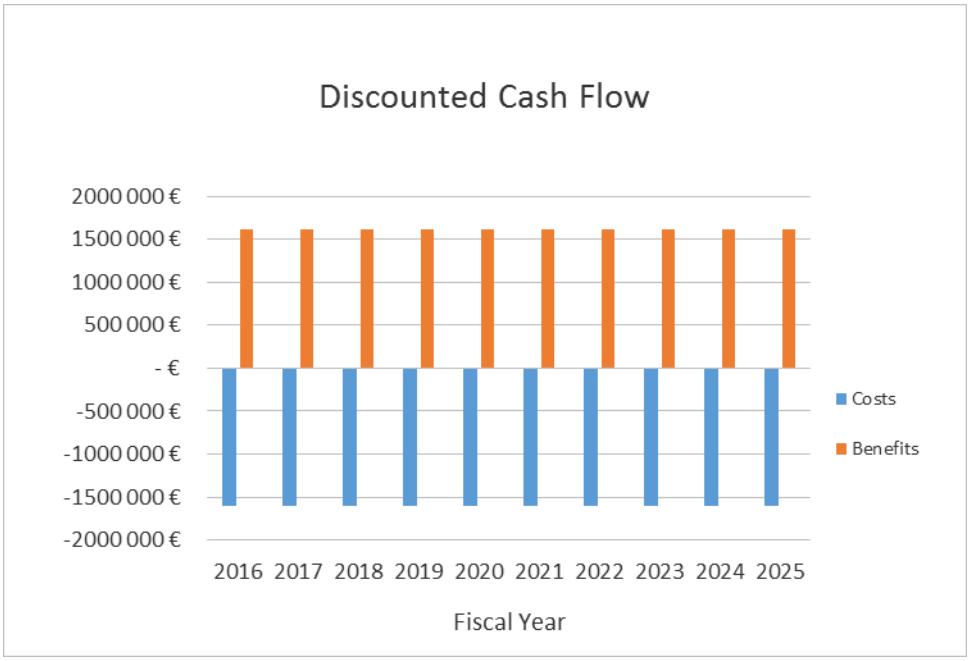

Figure 7: Discounted cash flows of Scenario 2

In figure 7 discount factor is considered in 10 years' time. The final cost and benefits will decrease 0, 4% compared to the table 6 by the year 2025.

As a result, Net Present Value (NPV) is found 51 966 EUR at the end of 2025 and BCR 1, 0. Positive NPV value indicates that when using scenario 2 additional profit will be earned compared to scenario 1 or in this calculation base case. As a result, costs will decrease round 3000 € per year and benefits increase round 1869 €/y. Overall profit of 15 085 966 € in 10 years period will be gained.

One of the most important parameter at CBA is indicating payback period. The payback period for scenario 2 is similar to scenario 1 and be counted as the first fiscal year.

Scenario 3

In this current scenario, HW alternative 1 and Steel scrap alternative 2 were combined and compared to scenario 1 or in this calculation base case. There are three monetized costs that consists of: Treatment costs which are paid to the WHC for service; Steel scrap transportation and tare rental and benefits from base case as costs. Benefits from HW handling, Steel scrap selling and cost of base case as benefits were also monetized.

As the costs are greater than benefits no financial profit is gained. This scenario shows that there is significant change compared to base case. The cost for HW are the same as scenario 2. For Steel scrap average profit is round 151 €/t. Monetized costs and benefits sources are presented per year during 10 years in addition to grand total costs and benefits at the end of 2025 in first two tables [Appendix 3].

Annual total cost and benefits are shown for the period of 10 years both as undiscounted and discounted with the discount ratio of 0.04 [Appendix 3]. In the result of discounting, net cash flow and cumulative are found. Undiscounted and discounted cash flows are presented in figure 8 and 9, respectively.

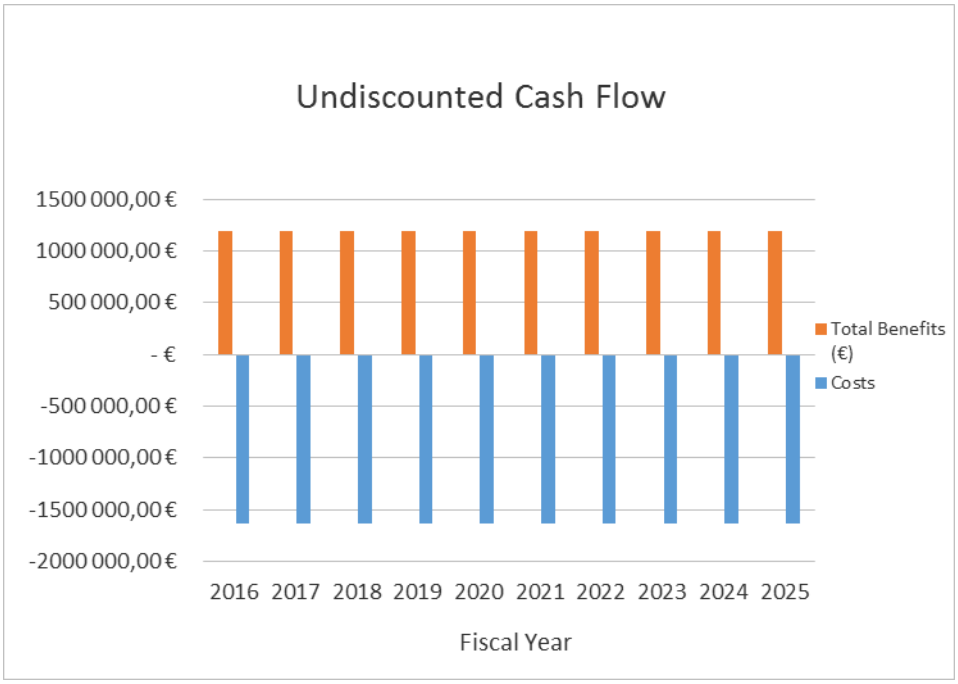

Figure 8: Undiscounted cash flows of Scenario 3

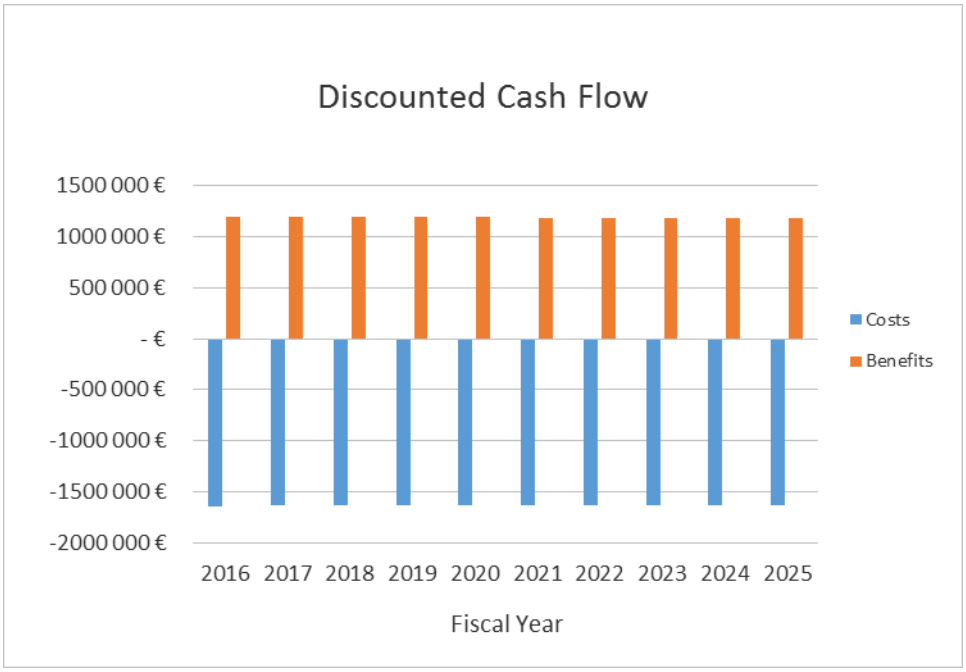

Figure 9: Discounted cash flows of Scenario 3

In figure 9 discount factor is considered in 10 years' time. The final cost and benefits will decrease 0, 4% compared to the table 8 by the year 2025.

In scenario 3 Net Present Value (NPV) is found -4 473 934 EUR at the end of 2025 and BCR 0, 73. Negative NPV value indicates that when using scenario 3 less profit will be earned compared to scenario 1 or in this calculation base case. As a result, costs for HW treatment will decrease round 3000 € per year but costs for Steel scrap transportation and tare rental increase by 30 935 €/y. Overall profit 10 560 066 € in 10 years period will be gained.

The payback period trend in this case with Discount Rate of 0, 04% will be negative as it starts to lose profit from the first fiscal year.

4.2. Monetization and of costs and benefits with NPV and BCR of HW and Steel scrap handling

As the result of partial CBA of the three scenarios, NPV, BCR and BEP are found for each one. As it has been discussed in methodology part, these parameters are economically crucial for decision makers. Table 10 represents the results for each scenario.

Table 10: Comparison of the alternatives with NPV, BCR and BEP

	NPV	BCR	BEP	Profit by 2025
Scenario 1 as Base Case	15 034 000 €	-	2016	15 034 000 €
Scenario 2	51 966 €	1,0	2016	15 085 966 €
Scenario 3	-4 473 934 €	0,73	-	10 560 066 €

In detail, for Scenario 2 and 3 positive NPV is desired, as they show increase or decrease of base case profit in 10 years. It must be known that a positive Net Present Value indicates that the projected earnings generated by a project or investment exceeds the anticipated costs.

BCR is profitable when considered to be greater than 1 and BEP should be as early as possible. It is seen that scenario 2 gives the best results for NPV and BCR, as the profit in 10 years is 15 085 966 EUR.

In fact, this result proves that, the AS Norma uses financially the best possible method for HW handling. However, the limitations for each scenario that may affect the results, should be taken into consideration before any decision making. Also, the sensitivity analysis is crucial for each scenario and need to be discussed.

4.3. Sensitivity Analysis of HW handling

It must be known that there are always likely substantial uncertainties about the calculations in CBA analysis. The significance of monetized sources can change and that may affect the results either positive or negative way. To see the results of the study, additional analysis is done.

Usually, the change of NPV is discussed depending on the discount rates. The discount rate used in current study is 0.04. In sensitivity analysis, NPV will be calculated with the discount

rates of 0.03 and 0.07 and compared with the discount rate of 0.04 which can be named as base. In table 11 results of Scenario 3 are presented. It must be known that when the discount rate gets lower, the NPV gets higher. It means, the value of the project is higher at lower discount rates. On the other hand, discounting the project with the discount rate of 7%, the NPV lowers by 0, 1% so the difference is not significant.

In this circumstances calculation of scenario 1 and 2 will not be meaningful as both of the scenarios prices are based on contracts and will not change during the contract period. For scenario 3 there is possibility to make a partial sensitivity analyze because alternative 2 from Steel scrap is used and prices given are not bound to contracts.

Table 11: Discount rates of 3% and 7% compared to 4% base, Scenario 3

Assumptions	NPV – Cost [€]	NPV – Benefits [€]	NPV – Total [€]
Px = 3%	- 1 634 183 €	1 187 193 €	- 4 475 946 €
Px = 4%	- 1 632 714 €	1 186 124 €	- 4 473 934 €
Px = 7%	- 1 628 314 €	1 182 929 €	- 4 467 908 €

The total NPV is still negative with 7% discount rate and it gets smaller with the discount rate of 3%. The loss of the total NPV between 4% and 7% is 6026 EUR in 10 years whereas there is 2012 EUR profit with the 3% discount rate compared to 4%.

In addition, it is important to analyze the change in costs sources to see the variations of total NPV after 10 years. The cost sources are increased and decreased by 20% and how the total NPV will correspond to this is analyzed. Decrease of cost will end up with a higher NPV as desired. Table 12 shows the numbers for scenario 3. The total NPV is increased and decreased by 63 196 EUR and the profit in case of 20% increase of whole cost will be 10 498 307 EUR.

Table 12. Assumptions altered for the cost sources of Scenario 3

Assumptions	NPV Total [€]
%20 Increase	-4 535 693 €
%20 Decrease	-4 410 738 €
Base	-4 473 934 €

Owing to the fact that scenario 3 has lower benefits and greater cost, the response to this change is normal.

To sum up, the likely changes that may occur over 10 years have been tried to analyze for the scenarios. The results showed that if NPV and BEP are considered then scenario 2 is suitable to use over for base case.

The CBA shows that the scenario 2 is considered to be most profitable and scenario 3 less profitable when compared to scenario 1. Also, NPV change over the years with different discount rates is not vital.

4.4. Environmental and social analyze

All waste types discussed previously are considered as a hazardous substance. In order to reduce the environmental impact HW are handled by licensed companies. The chosen companies assessed in this thesis EcoPro AS, Ragn-Sells AS and Epler & Lorenz AS have all up-to-date management technologies to lessen environmental impact of HW. In addition, the purpose of the study was also to present the different principals of HW management in handling companies.

Table 13: Environmental and social comparison of HW companies.

Company	Economic model used	Technological solutions	Complex solutions
EcoPro AS	Prevent and eliminate non-compliant waste management service; use all resources sparingly; use the best available technology for waste treatment; to prefer a contractual relationship with a qualified and informed subcontractors and suppliers; to provide the necessary staff training and continuous improvement of skill.	waste collection and transportation; contaminated soil treatment; hazardous waste landfilling; mixed fuels preparation; physical-chemical treatment; recycling of waste.	Collection of all mentioned waste types;
Ragn-Sells AS	Promote environmentally sound and economically viable waste reuse	waste collection and transportation; waste handling and reselling; export.	WO and filter materials collection; preventive solutions development service for preventing or reducing the total waste generation on client sites; Comprehensive customer solution development
Epler & Lorenz AS	waste recovery promotion; economic use of resources; waste generation reduction; reduction of environmental pollution.	waste collection and transportation; waste incineration waste incinerator; waste composting and soil purification; preparation of waste fuels; recycling of waste.	Collection of all mentioned waste types; consultations and trainings; environmental reviews; pollution studies.

In chapter 3.2., table 1 possible service providers are listed and pre selection was made. Table 13 gives more accurate environmental and social aspects of selected companies.

As mentioned previously AS Norma has obligation to implement their business decisions in environmentally responsible and caring manner. Companies discussed can be considered to meet the requirements.

They all have been active in Estonia since beginning of 1990's. For addition, all companies have quality and environmental management certifications. Only difference between companies are the handling methods. As mentioned above Ragn-Sells AS is a Swedish origin company who only collects, transports and resells HW in Estonia. EcoPro AS is quite similar company. It is Estonian origin and in addition, deals with mixed fuels preparation, physical-chemical treatment and recycling of HW, also landfilling. Epler&Lorenz is the only company who deals with HW treatment applying incineration technology.

For Steel scrap both companies' core business is buying, processing and selling ferrous- and nonferrous scrap metal and both are Finnish origin companies. In Kuusakoski AS industrial metals and other materials are sold as raw material to Finland and elsewhere in the world. Both companies are currently able to recycle or reuse up to 90% of the materials collected – and in some cases even more. OÜ BLRT Refonda Baltic is aimed not only at providing the population, enterprises and government agencies a comprehensive range of services utilization of recycled materials, but also - at multilateral activities related to environmental protection and conservation of Earth's interior. For storage and shipment of scrap metal is used the area adjacent to the seaport terminal.

To sum up all the companies that where further studied are environmentally conscious and responsible companies. When co-operational partners are considered the final decision should be guided by results of CBA presented.

5. Conclusion

The purpose of this study is to assess possibilities of hazardous waste utilization management in AS Norma. For this purpose, different companies were discussed and best possible options were further analyzed. To obtain better results HW and steel scrap was analyzed separately because of different methods are used to handle these wastes. For HW two different alternatives have been determined in addition for Base Case. First alternative is to use Ragn-Sells AS and the second alternative is to use Epler & Lorenz AS as a service provider. Pre selection of possible co-operational partners was made. For Steel scrap also pre selection of companies were made and two alternatives Kuusakoski AS and BLRT Refonda Baltic OÜ were further analyzed additionally to Base Case.

To analyze whether any of chosen alternatives would be economically profitable for AS Norma, a partial cost benefit analysis (CBA) has been used. As the method for the partial CBA has been determined, a discount rate of 4% was derived, based on optimal growth rate. To continue with, the analytical framework of Boardman et al. for CBA has been followed.

For financial assessment three different scenarios were combined based on HW and Steel scrap CBA. Epler & Lorenz and Kuusakoski AS were not included in presented scenarios as they were most costly or least profitable.

Related costs and benefits that can be quantified and monetized, were discussed. As mentioned previously for HW handling two possible options remained and were analyzed as alternatives. Secondly, Steel scrap handling possibilities were determined and analyzed.

As result of preliminary economical investigation by partial CBA, the crucial parameters such as NPV, BCR and BEP have been calculated and CBA for 10 years period has been done. Undiscounted and discounted cash flows, NPV, BCR and BEP have been presented for each scenario.

The best results are taken from scenario 2 with the NPV of 51 966 EUR, BCR 1, 0 and overall profit of 15 085 966 EUR. It is followed by scenario 1 where the NPV, are respectively,

15 034 000 EUR. The least desired results are from scenario 3. It has the BCR 0, 73 and NPV of -4 473 934 EUR compared to scenario 1 or in this calculation base case. With scenario 1 and 2 the BEP trend is positive and is considered to be the first fiscal year but in case of scenario 3 the trend is negative and decrease of profit starts from the fiscal year.

However, some present limitations for each scenario has been discussed and should be taken into consideration before any action plan.

Secondly, a sensitivity analysis has been carried out. To examine the results and robustness of CBA. Analyzes where calculated based on different discount rates and for addition increasing and decreasing of the cost sources where done.

With scenario 1 and 2 the calculation has not been carried out because prices are based on contracts and will not change during the contract period. For scenario 3 partial analyze was carried out. The differences between 7%, 4% and 3 % were 0, 1% and therefore not significant.

In environmental side all companies are very similar. The experience in Estonian market and management systems are rather the same. All companies aim to reduce environmental impact through their work.

For HW handling all alternatives and Base Case scenario management processes are up-to-date environmentally friendly companies. All are ISO certificated and aimed to act most in an environmentally friendly manner. They all have same amount of experience in Estonian market and are aimed to reduce environmental impact through their work. Companies try to send as much waste to recovery as possible. For the Steel scrap handling companies the aim is the same.

In general, it can be concluded that at the moment AS Norma is using financially the best solution for HW handling. As research show in Estonia there is a lack of companies that can provide services for certain HW type. For Steel scrap using three different companies AS Norma gets the best price from market but when one co-operational partner is wanted then based on this thesis the best option would be Refonda Baltic OÜ presented as alternative 2. This study results only preliminary economic feasibility of HW utilization possibilities.

Kokkuvõte

Antud lõputöö eesmärgiks on AS Normas tekkivate ohtlike jäätmete utiliseerimise võimaluste hindamine. Võimalikud ettevõtted on läbi arutatud ning nendest parimad lahendused on täpseimalt analüüsitud. Paremate tulemuste saamiseks on ohtlike jäätmeid ja metallijäätmeid käitlevad ettevõtteid analüüsitud eraldi. Ohtlike jäätmete osas on lisaks põhinäitele käsitletud kahte alternatiivi. Esmaseks alternatiiviks on ettevõtte Ragn-Sells AS'i ning teiseks ettevõtte Epler & Lorenz AS'i teenuste kasutamine. Ettevalmistuste osas viidi läbi võimalike koostööpartnerite eelvalik. Ka metalljäätmete osas toimus eelvalik ning lisaks põhinäitele analüüsiti lähemalt kahte alternatiivi: ettevõtteid Kuusakoski AS ja BLRT Refonda Baltic OÜ.

Analüüsimaks, kas mõni valitud alternatiividest oleks majanduslikult tulus AS Norma'le viidi läbi osaline tasuvusanalüüs (CBA). Osalise CBA meetod on kindlaks tehtud ning 4% diskontomäär on tuletatud, põhinedes optimaalse kasvule määrale. CBA jätkamiseks on järgitud Boardman'i analüütilist raamistiku.

Parema ülevaate saamiseks kolm erinevat stsenaariumi on loodud. Kombineeritud on erinevaid ohtlike jäätmete utiliseerimise võimalusi metallijäätmete utiliseerimise võimalustega. Ära tuleb mainida, et Epler & Lorenz AS ja Kuusakoski AS ei kajastu esitatud stsenaariumites seetõttu, et nad olid kas kõige kulukamad või vähem tulusamad.

Kõik seonduvaid kulud ja tulud, mida saab mõõta ja mis on rahasse arvutatavad, arutati. Nagu eelnevalt mainitud on ohtlike jäätmete käsitlemiseks kaks võimalust mida analüüsiti võimalike alternatiividena. Lisaks määrati kindlaks ja analüüsiti metallijäätmete käitlemise võimalusi.

Tulemused on esitletud erinevate stsenaariumitena. Stsenaarium ühes, käesoleva lõputöös esitatud kui põhinäide, ohtlike jäätmete põhinäide kui ka metallijäätmete põhinäide on kombineeritud ja analüüsitud. Teises stsenaariumis ohtlike jäätmete alternatiiv 1 ja metallijäätmete põhinäide on kombineeritud ning kolmandas stsenaariumis ohtlike jäätmete alternatiiv 1 ja metalljäätmete alternatiiv kaks on kombineeritud ja analüüsitud.

Põhinedes osalisele CBA analüüsile, esialgne majanduslik analüüs on läbi viidud. Otsustavad parameetrid nagu nüüdisväärtus (NPV), tulude-kulude suhe (BCR) ja tasuvusaeg (BEP) on arvutatud ja CBA 10 aasta tulemused on kalkuleeritud. Iga stsenaariumi kohaselt diskonteerimata kui diskonteeritud rahavood, NPV, BCR ja BEP on esitatud.

Parimad tulemused on saadud stsenaarium kahest, kus NPV väärtuseks on 51 966 eurot ja kalkuleeritud BCR on 1, 0. Kogukasumi väärtus 15 085 966 eurot. Sellele järgneb stsenaarium üks, kus NPV on vastavalt 15 034 000 eurot. Kõige vähem soovitud tulemusi on andnud stsenaariumi 3. Võrreldes stsenaarium ühega on BCR väärtuseks 0, 73 ja NPV -4 473 934 eurot. Nii stsenaariumi 1 ja 2 BEP trend on positiivne ning kasumlik juba esimesest majandusaastast. Stsenaarium 3 trend on seevastu negatiivne ja kasumi vähenemine algab juba esmasel rahandusaastal.

Ennem tegevuskava loomist tuleks arvesse võtta mõningaid piirangud, mis iga stsenaariumi kohta on välja toodud.

Lisaks on läbi viidud tundlikkuse analüüs CBA tulemuste ja stabiilsuse hindamiseks. On teostatud analüüsid, kus arvutatakse erinevat diskontomäära ning suurendatakse ja vähendatakse kulu allikaid.

Stsenaariumiga 1 ja 2 arvutus läbi ei viida kuna hinnad põhinevad koostatud lepingutel, mis ei muutu lepingu kehtivuse ajal. Stsenaariumi 3 põhjal koostati osaline analüüs. Erinevused 7%, 4% ja 3% vahel olid 0, 1%, seega mitte märkimisväärsed.

Ohtlike jäätmete käitlemise ettevõtete juhtimise protsessid on ajakohased ja oma tegevustel keskkonnasõbralikud. Kõik omavad ISO sertifikaate ning tegutsevad keskkonnasõbralikul viisil. Neil kõigil on sama palju kogemust Eesti turul ning eesmärgiks on seatud läbi oma töö vähendada keskkonnamõjusid. Peamiseks eesmärgiks on võimalikult suur protsent käideldavatest jäätmetest taaskasutada. Sarnased eesmärgid on ka metallijäätmete käitlemise ettevõtetel.

Üldiselt võib järeldada, et hetkel kasutab AS Norma finantsiliselt parimat meetodit ohtlike jäätmete utiliseerimiseks. Nagu uuring näitas napib Eestis ettevõtteid, mis võivad osutada teatud tüüpi ohtlike jäätmete utiliseerimise teenused. Kasutades kolme erinevat

koostööpartnerit metallijäätmete utiliseerimiseks võimaldab AS Normal saada parimat turuhinda. Juhul kui soovitakse minna üle ühe teenuse pakkujale, siis põhinedes antud uurimustööle on parimaks alternatiiviks BLRT Refonda Baltic OÜ. Silmas tuleb pidada, et antud uurimustöös on esitatud ainult esialgne majanduslik teostatavus ohtlike jäätmete utiliseerimiseks.

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Appendix 1

Scenario 1 as Base Case	Fiscal Year									
Cost Source	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Treatment Cost (€)										
Rental Cost (€)										
Base Case [€]	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €
Total Cost per year (€)	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €
Grand Total Cost (€)	524 480,00 €									

Scenario 1 as Base Case	Fiscal Year									
Undoscounted Flow	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Costs	-52 448,00 €	-52 448,00 €	-52 448,00 €	-52 448,00 €	-52 448,00 €	-52 448,00 €	-52 448,00 €	-52 448,00 €	-52 448,00 €	-52 448,00 €
Benefits	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €
Net Cash Flow	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €	1 506 107,00 €

Discount Factors										
Discount Rate	0,04%									
Base Year	2016									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1,0000	0,9996	0,9992	0,9988	0,9984	0,9980	0,9976	0,9972	0,9968	0,9964
Discounted Flows	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Costs	-52 448 €	-52 427 €	-52 406 €	-52 385 €	-52 364 €	-52 343 €	-52 322 €	-52 301 €	-52 280 €	-52 260 €
Benefits	1 558 555 €	1 557 932 €	1 557 309 €	1 556 686 €	1 556 064 €	1 555 442 €	1 554 820 €	1 554 198 €	1 553 577 €	1 552 955 €
Net	1 506 107 €	1 505 505 €	1 504 903 €	1 504 301 €	1 503 700 €	1 503 098 €	1 502 497 €	1 501 897 €	1 501 296 €	1 500 696 €
Cumulative	1 506 107 €	3 011 612 €	4 516 515 €	6 020 816 €	7 524 515 €	9 027 614 €	10 530 111 €	12 032 008 €	13 533 304 €	15 034 000 €

Net Present Value	15 034 000 €
Internal Rate of Return	-
BCR	-

Appendix 2

Scenario 2	Fiscal Year									
Cost Source	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Transportation Cost (€)	- €	- €	- €	- €	- €	- €	- €	- €	- €	- €
Treatment Cost (€)	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49111,00 €	49111,00 €
Base Case [€]	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1558555,00 €
Total Cost per year (€)	1 607 666,00 €	1 607 666,00 €	1 607 666,00 €	1 607 666,00 €	1 607 666,00 €	1 607 666,00 €	1 607 666,00 €	1 607 666,00 €	1 607 666,00 €	1607666,00 €
Grand Total Cost (€)	16 076 660,00 €									

Scenario 2	Fiscal Year									
Undoscounted Flow	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Costs	-1 607 666,00 €	-1 607 666,00 €	-1 607 666,00 €	-1 607 666,00 €	-1 607 666,00 €	-1 607666,00 €	-1 607666,00 €	-1 607666,00 €	-1607 666,00 €	-1 607 666,00 €
Benefits of HW (€)	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1869,00 €	1869,00 €	1869,00 €	1 869,00 €	1 869,00 €
Benefits of SS (€)	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558555,00 €	1 558555,00 €	1 558555,00 €	1 558 555,00 €	1 558 555,00 €
Cost from from base case as benefit	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52448,00 €	52448,00 €	52 448,00 €	52 448,00 €	52 448,00 €
Total Benefits (€)	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €	1 612 872,00 €
Net Cash Flow	5 206,00 €	5 206,00 €	5 206,00 €	5 206,00 €	5 206,00 €	5206,00 €	5206,00 €	5206,00 €	5 206,00 €	5 206,00 €

Discount Factors										
Discount Rate	0,04%									
Base Year	2016									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1,0000	0,9996	0,9992	0,9988	0,9984	0,9980	0,9976	0,9972	0,9968	0,9964
Discounted Flows	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Costs	-1 607 666 €	-1 607 023 €	-1 606 381 €	-1 605 738 €	-1 605 096 €	-1 604 455 €	-1 603 813 €	-1 603 172 €	-1 602 531 €	-1 601 890 €
Benefits	1 612 872 €	1 612 227 €	1 611 582 €	1 610 938 €	1 610 294 €	1 609 650 €	1 609 007 €	1 608 363 €	1 607 720 €	1 607 077 €
Net	5 206 €	5 204 €	5 202 €	5 200 €	5 198 €	5 196 €	5 194 €	5 191 €	5 189 €	5 187 €
Cumulative	5 206 €	10 410 €	15 612 €	20 812 €	26 009 €	31 205 €	36 398 €	41 590 €	46 779 €	51 966 €

Net Present Value	51 966 €
Internal Rate of Return	
BCR	1,003

Appendix 3

Scenario 3	Fiscal Year									
Cost Source	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Transportation Cost (€)	13 534,00 €	13 534,00 €	13 534,00 €	13 534,00 €	13 534,00 €	13 534,00 €	13 534,00 €	13 534,00 €	13 534,00 €	13 534,00 €
Treatment Cost (€)	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €	49 111,00 €
Rental Cost (€)	17 401,00 €	17 401,00 €	17 401,00 €	17 401,00 €	17 401,00 €	17 401,00 €	17 401,00 €	17 401,00 €	17 401,00 €	17 401,00 €
Base Case (€)	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €	1 558 555,00 €
Total Cost per year (€)	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €	1 638 601,00 €
Grand Total Cost (€)	16 386 010,00 €									

Scenario 3	Fiscal Year									
Undoscounted Flow	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Costs	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €	-1 638 601,00 €
Benefits of HW (€)	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €	1 869,00 €
Benefits of SS (€)	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €	1 136 085,00 €
Cost from base case as benefit (€)	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €	52 448,00 €
Total Benefits (€)	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €	1 190 402,00 €
Net Cash Flow	-448 199,00 €	-448 199,00 €	-448 199,00 €	-448 199,00 €	-448 199,00 €	-448 199,00 €	-448 199,00 €	-448 199,00 €	-448 199,00 €	-448 199,00 €

Discount Factors										
Discount Rate	0,04%									
Base Year	2016									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1,0000	0,99960	0,99920	0,99880	0,99840	0,99800	0,99760	0,99720	0,99681	0,99641
Discounted Flows	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Costs	-1 638 601 €	-1 637 946 €	-1 637 291 €	-1 636 636 €	-1 635 982 €	-1 635 328 €	-1 634 674 €	-1 634 020 €	-1 633 367 €	-1 632 714 €
Benefits	1 190 402 €	1 189 926 €	1 189 450 €	1 188 975 €	1 188 499 €	1 188 024 €	1 187 549 €	1 187 074 €	1 186 600 €	1 186 125 €
Net	-448 199 €	-448 020 €	-447 841 €	-447 662 €	-447 483 €	-447 304 €	-447 125 €	-446 946 €	-446 767 €	-446 589 €
Cumulative	-448 199 €	-896 219 €	-1 344 059 €	-1 791 721 €	-2 239 204 €	-2 686 507 €	-3 133 632 €	-3 580 578 €	-4 027 346 €	-4 473 934 €

Net Present Value	-4 473 934 €
Internal Rate of Return	
BCR	0,73