IIIEE Theses 2006:10

Assessing the practical relevancy of environmental cost accounting for industrial waste

Waste accounting, process efficiency and cleaner production

Raphaël Jachnik

Supervisors:

Håkan Rodhe

Torbjörn Brorson

Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, October 2006

Published in 2006 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
Tel: +46 – 46 222 02 00, Fax: +46 – 46 222 02 10, e-mail: iiiee@iiiee.lu.se.

ISSN 1401-9191

Acknowledgements

Spending most of the summer in front of a computer trying to come up with clever ideas and then put them down on paper is quite a challenging thing to do. Even though I am glad this period is now over, it has been a very interesting learning process to go through, which has been facilitated by quite a few people whom I would like to thank:

- Håkan and Torbjörn, my two supervisors, for reading through my work at all steps, and giving me constructive feedback and comments throughout the summer;

- Natlikan Sustainability and its Director, Magnus Agerström, for the financial and logistical support he provided me with, as well as Natlikan staff members in Malmö, in no particular order Elena, Jessica, Bigge, Ylva, Mattias, Christina, Sven and Julie for making the office an enjoyable place to spend the day;

- Kristofer Cook for his advices and feedback at the earlier stages of the project;

- All interviewees at the companies and production sites reviewed, for their availability, often just before leaving for holidays, for their transparency in answering the questions, and for their efforts to communicate with me in English;

- Finnveden for accepting to be a case study company, and Anne Lexe in particular, for her availability in July, and her help in organising complementary interviews later on during the summer.

Looking back at the 14 months spent in Sweden as a whole, I would like to acknowledge the role of the IIIEE in making possible the gathering of students from the five continents. The main richness of the programme lies in the confrontation of different cultures, backgrounds, views on the world and ways of thinking.

I would like to thank all Batch 11 students for what they voluntarly or indirectly taught me, and for making this year colourful, full of laughters and good memories that we will keep with us long after leaving Sweden. I want to mention a few batchmates in particular who made this year even more special: Pat mon pote geilomat, Nathan and Bronwen my fellow flatmates, Nata chevre!, Paolita mi hermanita, Amalka and our future common zapoi in Krakow, and 'wonderrrful' Giulia.

The last person I want to mention is also the most important one for me. She makes my life meaningful and joyfull, gives me the strength and a reason to overcome challenges and achieve things, makes me look at the future as a world of possibilities. Любимая! Каждый день, просыпаясь утром, я благодарю судьбу за встречу с тобой. Ты делаешь меня счастливым. Рядом с тобой я становлюсь лучше. Дзякуй.

Merci à tous!

Abstract

The main purpose of the Thesis work is to conduct an assessment of both the way companies currently account for their waste costs, and of the potential relevancy of engaging in a more comprehensive cost accounting for waste in terms of achieving industrial waste minimisation and cost optimisation. In order to do so, literature about environmental and cost accounting was reviewed, current practices at 20 Swedish industrial companies and production sites were assessed, and a case study was conducted with one of the companies previously interviewed.

The main findings of the research are that:

- As expected, the gap between concepts developed by academics and what companies are doing in practice is big. Most companies and production sites reviewed do not have any cost accounting in place for process waste, and consider it as an environmental issue to be kept under control rather than a production-related cost indicating existing inefficiencies in the manufacturing process;

- A majority of companies do not appear to have a strong interest in engaging in cost accounting for their waste. Although sometimes justified by the possible irrelevancy of waste accounting in their specific case, it is believed that such unwillingness is often based on an underestimation of the real amount of waste-related costs;

- Many factors can have an influence on the degree of relevancy of waste accounting for a particular company. The ones selected based on the empirical review and the case study include the current definition of waste costs at the company/site reviewed, the existing cost accounting for defects, the data and resource availability to engage in waste accounting, the quantities, types and origins of the waste generated, the proportion of raw material in total production costs, as well as the level of raw material efficiency;

- Waste accounting is found to be environmentally and economically relevant, but it appears that a 'one-size fits all' solution for all companies is not appropriate. Implementing waste accounting has to be done in accordance with case specific characteristics and needs. However, a broad five-step approach to be able to run an initital evaluation of the degree of relevancy of waste accounting at a given company was drafted: It consists of (1) understanding the industry, (2) gathering information/data and understanding waste-related costs, (3) analysing and identifying specific needs, (4) developing an appropriate performance metric, and (5) recommending management applications.

Key words: industrial waste, cost accounting, cost allocation, material efficiency, waste minimisation, cost reduction

Executive Summary

Industrial waste represents the majority of the waste generated in most countries. From the perspective of the industry, it is often identified as a main environmental aspect related to manufacturing operations, and if not yet, it is likely to become an area of focus soon, due to quite a few influential factors. Such factors include increasing regulatory pressures in the European Union (EU) and many other countries, companies being held more and more accountable for the environmental impacts of their activities, as well as fierce cost competition in many sectors of activity, with environmental concerns such as waste becoming a core aspect of any cost optimisation strategy.

While companies usually acknowledge that waste generation is a non-value adding activity, fewer of them realise that it is also a sign of inefficiency in systems and processes that could often be avoided. This is because the production of waste has traditionally not been linked to manufacturing efficiency, and, as a result, the management of waste-related costs has not been viewed as something relevant to focus on. As a starting basis for the Thesis, the assumption is made that this situation is mainly due to incomplete information about the real cost of the waste generated by industrial companies. Thus, the main research question is formulated as follows:

To what extent and under which conditions is it relevant, both from an environmental and economical point of view, for industrial companies to expand their definition of waste costs towards full cost accounting?

The primary aim of the research is to understand and analyse the way in which, as part of their performance management activities, industrial companies are, could and should be measuring and accounting for the cost of the waste they generate during the production process. This is to be achieved by assessing under which conditions and to what extent it is relevant for them to expand their current definition of waste costs, for example by including, if not already done, less obvious aspects than the cash cost of waste (i.e. collection, treatment and disposal costs). Additional costs that can be accounted for include the purchasing price of wasted raw materials, other direct and indirect production costs, as well as risk related, and even sometimes external costs.

The Thesis work was conducted in five successive stages: initial screening and scoping of a relevant focus for the study, review of current practices in the industry and confrontation with concepts defined in the literature, analysis of the information gathered and development of a draft approach to assess the relevancy of waste accounting at a given company/site, proceeding of a case study with one of the companies interviewed, and drawing of conclusions and recommendations.

The first chapter of the body of the Thesis report (Chapter 2) consists of a presentation and discussion of key definitions and concepts relevant to the research project. It is divided in three sections: The first one is an overview of relevant environmental and cost accounting principles and methods, with abundant conceptual literature found on those topics e.g. the concepts of Environmental Management Accounting (EMA), Full Cost Accounting (FCA), Full Private Cost Accounting (FPCA), and Activity Based Costing (ABC) are defined. The second section provides background information about industrial waste i.e. definitions, types and sources, management and minimisation strategies. The third section aims to link environmental accounting and industrial waste, by defining cost accounting for waste (or so called 'waste accounting'). EMA, FCA and FCPA are adapted to the specific aspect of waste, and the concept of Residual Waste Accounting (RWA) is introduced, as a calculation method allocating the main production costs (raw materials, labour, energy, maintenance) to process waste generated.

Chapter 3 is dedicated to the presentation and analysis of factors influencing the relevancy of waste accounting for the industry. Those were reviewed both in the literature and based on interviews conducted with 20 Swedish industrial companies and production sites. Results from the literature review and the empirical study are first presented separately before being confronted in order to present a draft approach that could be used when initiating waste accounting at a given company. As expected, the gap between concepts developed by academics and what companies are doing in practice is big. Most companies and production sites interviewed do not have any cost accounting in place for process waste, and consider it as an environmental issue to be kept under control rather than a production-related cost indicating existing inefficiencies in the manufacturing process. Moreover, a majority of companies do not appear to have a strong interest in engaging in cost accounting for waste. Although sometimes justified by the possible irrelevancy of waste accounting in their specific case, it is believed that such unwillingness is often based on an underestimation of the real amount of waste-related costs. Many factors can have an influence on the degree of relevancy of waste accounting for a particular company. The ones selected based on the empirical study and, to a certain extent, the literature reviewed, include: the current definition of waste costs at the company/site, the existing cost accounting for defects, the data and resource availability to engage in waste accounting, the quantities, types and origins of the waste streams generated, the proportion of raw material in total costs, as well as the level of raw material efficiency.

At the end of Chapter 3, a broad five-step approach to be used to run an initial evaluation of the degree of relevancy of waste accounting at any given company is drafted, based on the findings of the empirical study. The five steps are: (1) understand the industry, (2) gather information/data and understand waste-related costs, (3) analyse and identify specific needs, (4) develop an appropriate performance metric, and (5) recommend management applications.

Chapter 4 consists of a presentation of the partial case study conducted with Finnveden, an international engineering group producing components and systems based on metallic materials for the automotive industry. The case study includes a presentation of the company and an assessment of its current waste accounting and reporting procedures. As an outcome of the assessment, conclusions are drawn on the specific relevancy for Finnveden of various types of waste-related costs, as well as recommendations made on how to implement improved waste accounting and reporting procedures in the organisational context. The central recommendation made to the company is to initiate waste accounting by starting to account for the purchasing price of wasted steel. Metal scrap will then appear as a major cost to the business instead of being considered as an income due to the money received for it from the waste collection and treatment company. This in turn should enable to justify cleaner production initiatives, both on a continuous improvement basis (process optimisation), and by improving greatly the payback time for potential capital investments to enhance material efficiency.

In Chapter 5, results from the research are summarised with regard to the practical need for more complex waste accounting and reporting procedures, as well as the relevancy of waste accounting, both from an economical and environmental point of view. Waste accounting, RWA in particular, is found to be environmentally and economically relevant, but it appears that a 'one-size fits all' standard approach for all companies is not appropriate. Implementing waste accounting has to be done in accordance with case specific characteristics and needs. The five-step approach defined earlier can however be used as a starting point for an initial screening of a company's characteristics making it (or not) a potential candidate for waste accounting. Suggestions are also made, regarding the relevancy of environmental accounting both as a business opportunity for Natlikan Sustainability, as well as a potential area for further academic research.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Background information

Due to the pressure of a wide range of influences such as the increasing stringiness of environmental regulatory control and levels of green taxes, the growing requirements for disclosure of environmental information, the development of socially responsible investments, as well internal pressure for cost reduction and optimisation, organisations (private companies in particular), have to care about environmental issues more than they used to in the past.

As part of their marketing and public relation activities, many actually advertise themselves as being environmentally responsible, asserting to incorporate the management of their environmental aspects and impacts as a part or even 'pillar' of their core business strategies and decision-making procedures. However, despite the progresses made over the past decades in the field of corporate environmental management, decisions are often made with little support from relevant environmental cost information, as environmental data is usually reported, whether internally or externally, in terms of volumes of materials bought, quantities of waste generated or energy consumed. Corresponding cost information is usually treated as a one-line operating or administrative cost in the financial accounting system and is regarded as independent of production efficiency. Thus, firms frequently do not know the environmental costs of their business, because those costs have been too narrowly defined, often only as the cash-costs of complying with environmental regulations.

One of the objectives of environmental accounting (EA) is to attempt to help management assess the true environmental costs related to the activities of the business so these can be considered in decision-making, for instance when reviewing the costs and benefits of alternative actions versus status quo. When a firm understands the full financial benefits that can arise by reducing environmental impacts, it is more likely to adopt cleaner production practices that will reduce or even prevent those impacts. This is because decision makers will lead the company towards environmentally sound performance beyond legal compliance only if they think it is in the best financial interest of the company. Hence if they do not know how much their organisation or facility is really spending on pollution-related costs now, they cannot appropriately decide how much time and money it is worth to invest in the future in managing better and reducing pollution, such as waste and the wide range of direct and indirect costs that can be related to it.

1.2 Why waste costs?

1.2.1 The relevancy of industrial waste

Industrial waste represents the majority of the waste generated in most countries and is often a very significant portion of the total amount of waste to be dealt with in any given area, even small cities and suburbs. National statistics show that industrial waste represented more than 80% of the total of 90 million tonnes generated in 2002 in Sweden (Swedish Environmental Agency, 2005), and about 75% of the approximately 400 million tonnes of waste in the United Kingdom (UK) each year (UK Environmental Agency, 2006).[1] Thus, a public policy aiming at

[1] However, it should be pointed out that some specific waste streams/sources such as construction and demolition waste, account for a big share of IW, often more than waste from manufacturing and industrial sites. Thus, construction and demolition waste is very often classified separately to IW as such.

encouraging waste minimisation and prevention cannot avoid the issue of industrial waste. It is however interesting to note that most local, regional and national waste management plans within the European Union (EU) put much more efforts in the management of municipal solid waste than the industrial counterpart. This situation can be explained by various factors, among which the deregulation of most markets for industrial waste collection and treatment, and the lack of time, resources and knowledge among authorities to be able to deal with industrial waste in an appropriate manner.

From the perspective of the industry, waste is often identified as a main environmental aspect of manufacturing operations, and if not yet, it is likely to become an area of focus soon, due to quite a few influence factors among which:

- The increasing regulatory pressures in the EU and many other countries in the area of waste (e.g. extended producer responsibility programmes, restrictions with regard to waste going to landfills, restrictions and increasing costs for hazardous waste treatment and disposal, etc.). For companies, this is likely to increase waste-related compliance costs;

- Fierce cost competition in many sectors of activity, with environmental concerns, waste for instance, becoming a core aspect of any cost optimisation strategy. This might lead to companies realising that it can be more cost effective to prevent pollution rather than to clean-up i.e. minimise or even try to avoid waste rather than getting it collected, treated and/or disposed of;

- Companies being held accountable for the environmental impacts of their activities, which is of particular relevance for those industries generating hazardous waste and facing potential liabilities if responsible for any type of air, water or soil contamination i.e. cost of decontamination, fines, as well as less quantifiable costs related to the company's image being temporarily or permanently damaged.

1.2.2 Underestimating waste-related costs in the industry

While companies usually acknowledge that waste generation is a non-value adding activity, fewer of them realise that it is also a sign of inefficiency in systems and processes that could often be avoided. This is because the production of waste has traditionally not been linked to manufacturing efficiency, and, as a result, the management of waste-related costs has not been viewed as an area of focus for production facilities. On the contrary, quality management has seen many developments, with the cost of poor-quality usually being accounted for in a comprehensive way via the measurement of corresponding manufacturing costs of producing defects and/or the opportunity cost in terms of loss sales and revenues. It is likely waste management and accounting could be improved by following a similar path than the one taken by quality management.

From a theoretical point of view, the literature on EA provides an explanation for this: environmental costs, and waste costs in particular, are not being accounted for properly by traditional accounting systems i.e. waste costs are underestimated if only viewing the cost of environmental compliance. According to EA practitioners, environmental costs encompass a much broader scope of cost types than compliance costs, such as the costs of resources in production, the costs of resources in general business operations, internal waste treatment and disposal costs, and in some situations, costs of a poor environmental reputation, environmental risk insurance premiums, etc.. EA has been developed and is to be used to find these hidden costs and classify them correctly. By doing so, it is likely that a broad range of costs related to process inefficiencies (such as wasted raw materials, energy as well as labour) could be identified and, at least partly, accounted for as waste costs. This could actively participate in justifying waste reduction activities, and in turn generate cost savings.

From a more practical point of view, waste minimisation in the industry has traditionally been driven by technological improvements, with investments usually conducted for capacity increase or productivity improvement reasons, and the reduction of environmental impacts coming as a side benefit. However, it is likely that many cleaner production investments or material-substitution possibilities are not considered as viable and profitable by companies because of an underestimation of the real or true current cost of pollution for them. This can mean that many opportunities for cost savings and environmental improvement are being lost.Waste costs are likely to be a good example of it.

1.2.3 A gap between academic literature and practice

Already in 1994, a study entitled "Accountants' attitudes and environmentally-sensitive accounting", consisting of sending 1000 questionnaires to financial departments of major companies in the UK, showed the following paradox (Bebbington, Gray, Thomson and Walters, 1994):

- Accountants are aware that environmental issues will affect their practice in the future, perceive that this impact falls within the role of the accountant and view themselves as the appropriate individuals to innovate in this area;

- However, the level of environmental accounting activity remains very low or even inexistent, accountants not being highly involved in their companies' response to the environmental agenda.

According to the results of the study, the only area where accountants were involved in environmental aspects were those linked to traditional accounting areas such as disclosure of information to external parties.

Literature on the benefits of performance orientated internal environmental accounting has been continuously published over the past ten years. For instance, so called Environmental Management Accounting (EMA) has been developed within the academic world as a result of the growing appreciation of the lack of awareness and understanding that people within an organisation generally have with respect to the magnitude of the environmental costs being generated by their organisation. However, EMA methods are not being implemented on a large scale, which tends to show that there is still a gap between what academics, and to certain extent consultants as well, recommend implementing, and what companies actually do. Again, waste appears to be a good example of this and it is of academic interest to try and understand why it is so.

1.3 Research question

The main research question is formulated as follows:

To what extent and under which conditions is it relevant, both from an environmental and economical point of view, for industrial companies to expand their definition of waste costs towards full cost accounting?

Brief definitions of 'industrial waste' and 'full cost accounting' are given below. Both concepts will be further discussed and interpreted for the purpose of the research in Chapter 2.

A common approach to **industrial waste**, whether by the industry itself, public authorities, or waste management companies, is to refer to it as 'non-product output'. Non-product output stands for any unwanted material (whether pure or mixed) left over from a manufacturing process that are to be recycled (material recovery), composted (for organic materials), incinerated (combustion with, in some cases, energy recovery) or landfilled (disposed of). However, for the purpose of the research, this definition of industrial waste will be extended to sometimes cover those materials not included in product outputs but being reused internally or as by-products by another industry, as well as defect products or semi-finished products that need to be reprocessed or disposed of for quality reasons (cost of non-quality). Clarifications on this methodological choice will be presented in Section 2.2.3.

Full Cost Accounting (FCA) is usually referred to as a methodology to specifically measure and account for external and social costs. But in essence, it actually aims at identifying all types of costs that can be directly or indirectly related and allocated to a given activity, process, product, facility, company, project, etc. FCA therefore includes direct and indirect, hidden and overhead, tangible and intangible, past and future, as well as internal and external costs.

Now, in its correct formulation, FCA should include all external and social costs. However, because it is of great complexity to quantify environmental externalities, the research will focus on the identification, evaluation and allocation of costs within the organisation, so called 'private costs'. This can be referred to as **'Full Private Cost Accounting' (FPCA)**, private costs actually being what organisations are most likely to be interested in as those costs have a direct impact on their 'bottom line'. Externalities are however sometimes included in private costs when companies have been forced by law to internalise part or all of the external impact they generate e.g. climate change levy, landfill tax.

The acronyms FCA and FPCA will be used as reference points for the purpose of the research as they are the most comprehensive calculations that can be conducted i.e. they encompass all types of costs that can potentially be considered. There is a wide range of degrees of accounting complexity between no cost accounting at all and FCA. The purpose of the project is to assess the relevancy of moving from a less to a more comprehensive degree of cost accounting for indusrial waste.

Now, to be able to conduct the assessment as defined in the main research question above, multiple sub-questions have to be answered:

- How are environmental and more specifically waste costs defined in the accounting and/or environmental management literature? Is there a consensus and/or most appropriate manner to define and classify costs related to the generation of waste by industrial companies?

- How do companies currently define and account for their waste costs? How big is the gap between this and the accounting concepts described in the literature? Is what companies are doing the result of a thought process or of a lack of interest or focus, and is there a willingness among them to expand their current definition of waste costs to cover less obvious aspects such as direct and indirect production costs, or risk-related costs?

- Can a methodology be established to help a company decide the appropriate degree of complexity and comprehensiveness it should use when defining and accounting for its waste costs?

- Should waste costs actually be considered as so called 'environmental costs' or would it be easier to mainstream waste minimisation strategies by looking at them as cost related to production efficiency?

- If proven that there is a need to generate a more comprehensive performance indicator for waste-related costs, how should such a metric look like? Where does it fit in the organisational context and what type of application can it be used for?

1.4 Aim

The primary aim of the research is to understand and analyse the way in which, as part of their performance management activities, industrial companies are, could and should be measuring and accounting for the cost of the waste they generate during the production process. This is to be achieved by assessing under which conditions and to what extent it is relevant for companies to expand their current definition of waste costs, for example by including, if not already done, less obvious aspects than the direct cash cost of waste (i.e. collection, treatment and disposal costs). Additional costs that can be accounted for include the purchasing price of wasted raw materials, other direct and indirect production costs, as well as risk-related, or even sometimes external costs.

The objective is however not to generate a parallel accounting system and to create full environmental accounts where all environmental costs would be presented (e.g. environmental balance sheet, pro-forma environmental financial statement, corporate environmental costs and revenues statement, etc.), but to try and understand how to identify, track, possibly allocate, and report waste costs in the most appropriate manner. This includes those waste-related costs that are currently 'hidden' and could be relevant for a production site to consider when assessing and managing its operational performance (e.g. production planning and sequencing, improving operating procedures) and making key decisions (e.g. investment appraisal, choice a supplier or raw material).

1.5 Scope and exclusions

The study focuses on the industrial sector, and more specifically individual manufacturing sites. Companies operating in the service and agricultural sectors are not covered. For the purpose of the study, the geographical scope was limited to production sites in Sweden, where all interviews as well as the case study were conducted.

The first half of the research project was aimed at getting a broad overview of waste accounting practices within the Swedish industrial sector and therefore covered a wide range of types of companies in various industries e.g. production of chemicals, food and dairy products, packaging, trucks and automotive components, industrial machinery and components, buildings/infrastructure and construction materials. The second stage of the project focused on the specific case of Finnveden Metal Structures, which develops, produces and sells interior and exterior metal structures for applications in cars and trucks. Using a production site as a partial case study, a more thorough assessment was run with practical recommendations made for initiating cost accounting for waste in the most relevant way.

The scope of the research being limited to industrial waste (including hazardous waste) generated during the manufacture of products, the physical boundary is therefore the factory itself, which excludes waste generated at the product's end of life, or any other life cycle aspects taking place outside of the production process. The focus is on what can be referred to as 'solid waste', with wastewater and air emission not being covered. This is however not a strict exclusion, as the usual approach to waste from production processes is to look at 'industrial waste' altogether i.e. solid and liquid waste (such as used oils).

Regarding wastewater, if a given production site has its own treatment system, the sludge generated as an output of the internal waste water treatment process falls under the solid waste category and the associated costs of treating the waste water and then the sludge are therefore included as part of the review. When it comes to air emissions, exceptions to the exclusion would in some cases include thick dust as well ashes from combustion, which have to be landfilled.

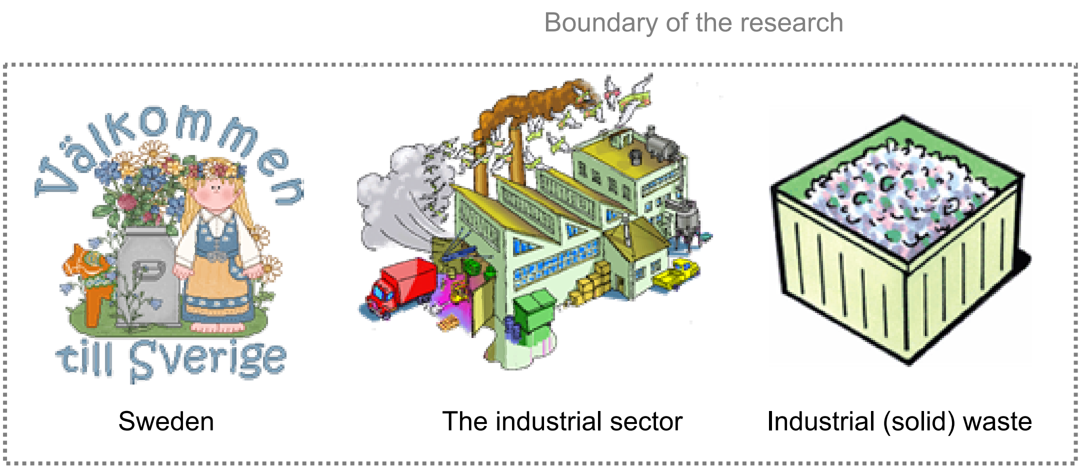

Figure 1: Scope of the research
Sources: Oulunkaaren Internetpalvelut, Ocegueda Productions and Denso Japan [2]

From a content perspective, the scope was initially limited to how manufacturing sites are and could be defining their waste costs; that is what types of costs are and could be included when accounting for the total cost of solid waste. Cost allocation procedures back to specific processes or stage of the production were to be covered to the extent possible given the time constraint and the practical complexity of doing so, as doing so requires a very deep understanding of the production process and materials flows at each stage. This is however the natural step following the review and eventual expansion of the existing definition of waste costs, and subsequent initial improvement of waste cost accounting practices. The financial modelling of potential cleaner production measures that could be taken or investments that could be made on the basis of the data generated by the proposed improved waste accounting system, are not covered by this study either. However, suggestions are made on potential application and uses of improved waste cost data.

[2] Pictures available from Oulunkaaren Internetpalvelut at: http://www.oulunkaari.net, Ocegueda Productions at http://www.oceguedaproductions.com, and Denso Japan[2] at http://www.denso.co.jp

The approach taken was pragmatic and focused on assessing the practical need for more complex cost accounting. Literature on management and environmental accounting was therefore only reviewed to provide a starting point and the basic concepts and definitions. An extensive review of all environmental management accounting methods presented in the literature was not conducted; this is because the purpose of the project was not to try to apply tools or concepts developed in the academic literature on environmental accounting, especially as they appear to be too advanced and complex to be implemented by companies on a broad scale.

1.6 Research design and methodology

As per the chronology below, the Thesis project was conducted in five successive stages: (1) initial screening and scoping, (2) review of current practices in the industry, (3) analysis of the information gathered and development of a methodology, (4) proceeding of a case study, and (5) drawing of conclusions. Relevant literature was reviewed during all stages of the project.

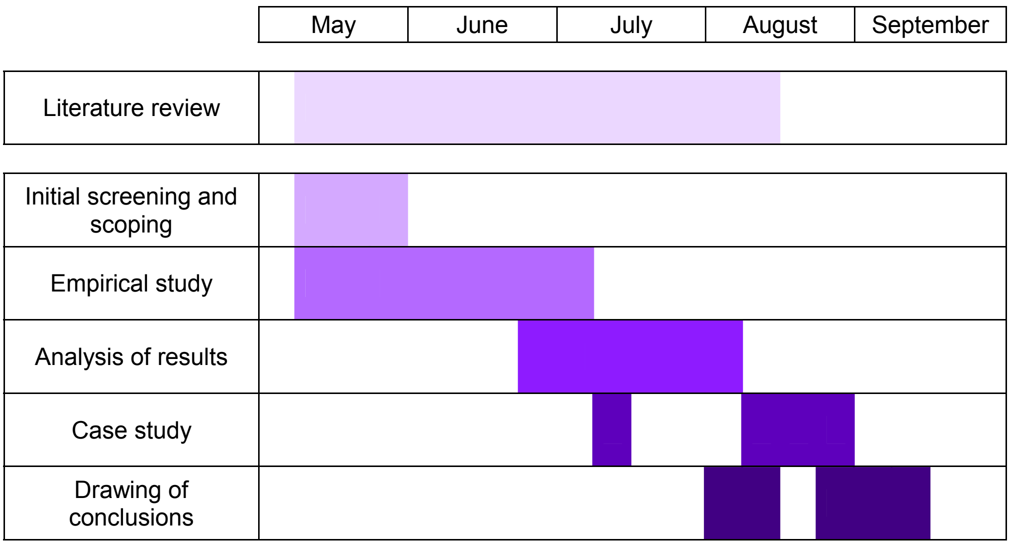

Figure 2: Steps of the research

(1) Initial screening and scoping (May)

This first stage took place during the second half of May. An initial draft research project idea was defined and summarised in about a page. The main focus was to try and identify cost reduction possibilities using EMA at a given case study company. This first draft was confronted both with some of the available literature and case studies on environmental and management accounting and its practical implementation, as well as a partial review of the current situation and needs in the industry in Sweden by running six initial interviews with environmental and quality managers at various industrial companies.

The initial screening enabled to identify a gap between theoretical literature describing EMA's principles and benefits (and often assuming its systematic relevance) on the one side, and the absence of implementation of environmental accounting within the companies interviewed on the other side i.e. absence of or very limited environmental cost information in those companies. A reviewed scope proposal was prepared by the end of May, suggesting to take a step back as well as to have a more empirical approach, in order to focus on assessing the practical relevancy of more comprehensive cost accounting for environmental aspects.

The decision was made to focus on waste, an environmental aspect that appeared to be of particular relevancy given the driving forces presented in Section 1.2.1.

(2) Assessing the state of the art

This second stage took place from the beginning of June to early July. Interviews were conducted with a wide range of production sites of companies from different industrial sector and different sizes to get an overview of current waste accounting practices. Specific production sites were contacted on the basis of a list of some of Natlikan Sustainability's current customers.[3]

A handful of additional companies were included to ensure that a minimum of about 20 interviews would be conducted. The objective of the interviews was both to get an understanding of what companies are doing as well as assess their interest in doing some work in the area of waste accounting, as it would be neither realistic nor feasible to try and force them to implement something they show no interest in at all.

In parallel, a more thorough literature review was conducted in various areas: management accounting, environmental and waste accounting, and industrial waste management. This was to allow both to identify key definitions and concepts, but also the drivers, expected benefits as well as barriers for the implementation of complex cost accounting methods and/or environmental accounting.

By the end of the interviewing process, a handful of companies had expressed an interest in looking into trying to improve the way they currently assess their waste costs. Out of those, one, Finnveden, showed a higher degree of motivation and availability in doing some work in this area, and was selected for a case study.

(3) Analysing the information collected

The third stage of the project, which consisted of analysing the information gathered during the second stage, was carried out throughout the month of July.

The outcome of the interviews was summarised and then analysed in order to outline some of the factors having an impact on the practical relevancy of waste cost accounting. These factors were confronted and/or complemented with the ones outlined in the reviewed literature.

On the basis of this analysis, a methodology was drafted in order to enable to approach a given manufacturing site for the purpose of screening its current waste costing and reporting practices, and assess the extent to which it could be extended and improved.

The case study was more specifically prepared by collecting information on the specific industry, reviewing some of the documentation provided by the case company, and running additional interviews with other staff members at the production site studied.

[3] Natlikan Sustainability is Sweden-based business consultancy supplying its customers with products and services within the fields of Environment and Health and Safety. Natlikan provided financial and logistical support for the Thesis work. More details about the company can be found at: http://www.natlikan.se/

(4) Running a case study and drawing conclusions

During the month of August, the case study was conducted. The methodology developed during the third stage was partially tested with the case company. Specific recommendations were made to the company with regards to the extent to which it should be expanding its current definition of waste costs, as well as the way to initiate the improvement of its waste accounting and reporting procedures within the organisational context.

(5) Drawing conclusions

Towards the end of August, the research work entered its final stage, consisting of summarising results and learnings to enable to draw conclusions and make recommendations.

1.7 Limitations

As for any research project, limitations have to be applied, due both to the methodology used as well as the scope definition. These limitations are presented in the following paragraphs.

1.7.1 Choice of the type and number of companies interviewed

The choice of manufacturing sites to be reviewed during the initial interviewing process was a half passive one. On the one hand, the decision was made to focus on industrial companies, but on the other hand, no pre-selection criteria were applied in order to assess the specific relevancy of each company for the purpose of the research.[4] Most companies contacted are current customers of Natlikan Sustainability, which are all fairly large enterprises. The approach would not have been the same if small and medium size enterprises (SMEs) had been targeted instead, but it is hard to instinctively assess how different the information collected during the interviews could have been. This is due to the fact that, even though quite many SMEs work with data from the profit and loss account rather than developing a proper cost accounting system, the assumption that large companies employ more advanced management methods is far from being always verified.

The choice to focus mainly on Natlikan's customers was made in order facilitate access to relevant staff members, and to ensure enough companies could be interviewed given the likelihood of those people not being available for interviews around the Swedish Midsommar and holiday period. It was also assessed that narrowing down the initial review to a specific industry or group of more homogeneous companies would not have been feasible without risking to be left with too few companies. It would also have prevented to draw more general conclusions than the ones specific to that industry. However, as a result of these methodological choices, the quality and relevancy of the information collected varied a lot from one interviewee to the other. In addition, the learnings and conclusions that could be drawn from the initial interviews remain quite general. Because a wide range of different types of manufacturing sites and companies were reviewed, the potential for going more in depth or focusing on a couple of specific factors relevant to one industry/type of company was limited. This was however to be compensated by the case study conducted at a later stage of the project and by looking at one specific industry for that purpose.

[4] Potential selection criteria could have included the size of the company and/or production site, the type of waste generated (e.g. only review companies generating hazardous waste), etc.

With regards to the transferability of the results and conclusions, the following comment can be made: The generic conclusions drawn from the multiple interviews are in principle applicable across a wide range of industries. The more specific conclusions drawn from the case study have to be treated with more cautious if wanting to transfer knowledge to another industry or company. However, the general approach taken remains of relevancy for other companies.

When trying to get an overview of current practices in the industry, one can never talk to enough actors. In the case of this project, the number of production sites interviewed was limited by various factors such as getting access to the right person at a given company/production site in the first place, the availability of potential interviewees, and the time constraint of having to run the interviews during the first month of the research (June) in order to be able to move to the analysis and case study stages soon enough. Ideally, a more comprehensive review should have been conducted with a larger sample population than 20 companie and production sites. However, given that a clear pattern already emerged from the interviews conducted, it can be assumed that a review of additional companies would have confirmed it, with the exception of finding a leading company having implemented an advanced system or so called 'best practice'.

1.7.2 The interviewees and the interviewing process

Another limitation to the representativeness of the information gathered during the interviews can be placed based on the variety of past experiences and current positions occupied by interviewees, which included corporate and site environmental and/or quality managers, environmental engineers and production managers, and controllers/management accountants.

This had an impact on the responses received, especially the more qualitative ones e.g. when enquiring whether the interviewee thought the current waste costing as appropriate and whether the existing definition of waste costs should be expanded. Ideally, all three types of actors at each production site should have been interviewed to get a full picture but this was not practically feasible. Since the lack of communication between the environmental and accounting departments is often mentioned in the literature as a flaw of traditional management and reporting procedures, one can assume that talking to one or the other at a given site did make a difference in the answers received. Environmental managers appear to have a lack of knowledge with regards to cost information, while accountants know little about environmental aspects. This was partly compensated by sending the questionnaires a couple of days before the planned date for the interview, which allowed, but only in a minority of cases, the interviewee to search for information or data he/she did not have or even to invite one of his colleagues to participate in the phone call.

Another factor that should be accounted for is the personal level of interest of the interviewee in the area discussed. It was not always possible to assess whether the opinions expressed by the interviewees were personal thoughts or whether they actually gave a good indication of the relevancy of waste accounting for the site as a whole. This limitation goes both ways, as it can be assumed that an interviewee having a personal interest in the issue, might overestimate the need for it beyond what the site and company managers would be ready to commit. This somewhat 'positive bias' has in theory not been avoided as most interviewees were environmental and quality managers (who can be expected to be more inclined to view the possibility of investing time in improving waste accounting) rather than accountants or controllers. In practice however, few interviewees expressed a strong and direct interest in getting some work done in this area, mainly because of time constraints and/or because assessing that this would be of little relevancy for their site. It is therefore not possible to evaluate to what extent the position occupied by the interviewee had an influence on the outcome of the discussion.

The format of the interviews also had an impact on the information gathered. To the exception of two companies, all interviews were conducted on the phone, which limited the interaction with the interviewee and the possibility to collect specific data and figures. A list of standard questions was prepared and sent to the interviewees prior to the meeting or phone call to facilitate the discussion. The interviews turned out to be only semi-directive as interviewees were left free to expand on specific aspects or issues they thought were of relevance. Moreover, not all questions were actually relevant in all cases, especially when talking to people with little knowledge and/or interest in waste cost accounting. Thus, only part of the questions were covered during some of the interviews.

Language was a slight issue as well, despite most interviewees being able to express themselves fluently in English. Some potential interviewees turned down the possibility of an interview because they would have needed additional time for preparation. Moreover, having people speak in English rather than their mother tongue also has an impact on the depth and level of detail in the answers. Given the fairly directive format of the questionnaire and the low number of obvious misunderstandings during the discussions, this should not be seen as a main issue. Language was more of a problem when running the case study, as most documents from the company were in Swedish. In order not to slow down the process too much, those were translated only to the extent necessary given the scope of the project.

1.7.3 The Swedish context

It can be assumed that companies in Sweden are traditionally and more than in other countries, transparent and proactive with regard to the management of environmental impacts of their activities, as well as open to suggestions for improvements.

Concerning the market for industrial waste management, the situation in Sweden can be described as semi-deregulated: regional public waste management companies share the market with private companies, while the treatment and disposal of the most hazardous streams remains a centrally-controlled activity. Similar situations can be found in other EU countries. Now, each of the regional or so called 'municipal waste management companies' has its own agenda depending on the main technology used (e.g. energy recovery from incineration, production of biogas from anaerobic digestion, etc.), therefore giving different incentives to companies, especially when it comes to the price they have to pay or money they get paid to get their waste collected. Because it has a direct impact on the cost of solid waste for the industry, this situation could partially limit the transferability of results, even within Sweden.

1.8 Outline

The next chapter (Chapter 2) consists of a presentation and discussion of key definitions and concepts relevant to the research project. It is divided in three sections: The first one is an overview of relevant environmental and cost accounting principles and methods, with abundant conceptual literature found on those topics. The second section provides background information about industrial waste i.e. definitions, types and sources, management and minimisation strategies. The third section is an intent to link environmental accounting and industrial waste, by defining cost accounting for waste (so-called 'waste accounting).

Chapter 3 is dedicated to the presentation and analysis of both the literature review and initial interviews conducted, which are first presented separately before being confronted in order to present a draft approach that could be used when inititating waste accounting at a given company.

Chapter 4 is a presentation of the partial case study conducted with Finnveden, including a presentation of the company and an assessment of its current waste accounting and reporting procedures. As an outcome of the study, conclusions are drawn on the specific relevancy for one of Finnveden's production sites of various types of waste-related costs, as well as recommendations on how to implement improved waste accounting and reporting procedures in the organisational context.

In Chapter 5, the conclusion, results from the research are summarised with regard to the practical need for more complex waste accounting and reporting procedures, as well as the relevancy of waste accounting, both from an economical and environmental point of view. Suggestions are also made regarding the relevancy of environmental accounting, both as a business opportunity for Natlikan Sustainability, as well as a potential area for further academic research.

2 Accouting for waste costs

In this chapter, general background information will be presented on both:

- Environmental and cost accounting (section 2.1), and
- Industrial solid waste management (2.2).

The third and last section will make the link between these two fields to define 'waste accounting' principles that will be referred to later in the analysis and case study presentation.

2.1 Environmental accounting

2.1.1 Accounting and the environment

Unless stated otherwise, the definitions provided and quotations used in this section are taken from the latest and most comprehensive guidance document on EMA, published in August 2005 by the International Federation of Accountants (IFAC).

Accounting, at the level of an organisation[5], can be broadly defined as the collection and aggregation of information for decision makers, both internal (e.g. managers) and external (investors, regulators, lenders, and the broader public) to the company.

There are usually two types of accounting within a company:

- Financial accounting, which "*is mainly designed to satisfy the information needs of external stakeholders such as investors, tax authorities and creditors, all of whom have a strong interest in receiving accurate, standardized information about an organization's financial performance*" (p. 12). Financial accounting focuses on monetary information and is regulated at the national level, most often on the basis of so called international 'Generally Accepted Accounting Principles' or G.A.A.P;

- Management accounting deals both with monetary and physical information, and "*primarily focuses on satisfying the information needs of internal management*", in order to "*inform management decisions and activities such as planning and budgeting*", and promote an "*efficient use of resources, performance measurement, and formulation of business policy and strategy*" (p. 12). Some management accounting procedures and methodologies have been developed, but as management accounting is an internal performance management system, each company is able to decide how it wants to organise and implement it.

Although considered as parallel information flows, there are in practice many interlinks between financial and management accounting systems within an organisation. As underlined, by the IFAC, "*bookkeeping can be seen as a data collection process that generates information for both internal and external audiences",* while *"total costs and earnings that may be calculated for management accounting purposes are related to the organization-wide revenues and expenditures collected for financial reporting purposes*" (p. 13).

[5] National accounting will not be discussed here

Information systems such as accounting are particularly strong behavioural drivers within the context of a corporation where profitability is the main daily concern. Thus, in order for environmental concerns to become more of a focus, they need to be included within those accounting systems. Doing so will inform and motivate behaviour towards linking sound environmental management with everyday business and decision-making. The understanding by both some environmental and accounting practitioners of the necessity of linking environmental data to accounting systems favoured the birth of EA, as a subset of the broader accounting systems.

EA is "*the provision of environmental-performance related information to stakeholder both within, and outside, the organisation*" (The Institute of Chartered Accountants in Australia, 2003, p. 10). Based on this definition and according to the traditional separation between financial and management accounting, the following split can be made between:

- Environmental Financial Accounting (EFA), which is aimed at external reporting of environmental and financial benefits in (sometimes verified) corporate environmental reports or published annual reports. EFA is partly governed by G.A.A.P. For instance, traditional corporate financial statements usually include environmental remediation and liability issues linked to a company's activity. However, because their magnitude is uncertain or even unknown, those are usually reported in a non-quantified and not-streamlined way e.g. footnotes. Some cost information can sometimes be included in externally published environmental reports by companies, but those costs are usually only describing the price paid to energy, waste and water contractors for consumption of resources and services rendered. Moreover, external and social costs are excluded. The existing weaknesses and inconsistencies observed in EFA can be explained by the fact that the demand for environmental information by the various actors of financial markets is fairly recent, and the reporting of such information by the companies is therefore an ongoing emerging process;

- EMA, which is "a*n accounting approach that considers the financial impacts of environmentally related activity such as the implementation of environmental protection expenditure, costs of legislative compliance and investment. The costs are allocated and tracked to meet the organisation's own business needs, mirroring the traditional management accounting techniques*" (UK Environmental Agency, 2006). EMA is aimed at enabling to take corrective management actions to reduce environmental impacts and costs, and is therefore a tool for environmental cost control and management in order to positively correlate economic and environmental performance.

The research focuses on the management and specifically cost side of EA.

2.1.2 Environmental cost accounting

In this section, EMA will be presented more in depth with a narrowing down to the even more specific field of Environmental Cost Accounting (ECA). This will be done using both environmental accounting specific literature as well as concepts and definitions from the broader field of management accounting and control, which EMA and ECA belong to.

2.1.2.1 Environmental management and cost accounting

Expanding on the definition given in the previous section, EMA consists of "*the identification, collection, estimation, analysis, internal reporting and use of materials and energy flow information,* *environmental cost information, and other cost information for both conventional and environmental decision-making within an organization*" (Environmental Management Accounting Research and Information Center (EMARIC), 2006).

There is however some confusion around this definition, as acknowledged by the IFAC itself: "*the language used for the different types of environmental accounting is not standardized* (…) *terminology differs among organizations and countries* (…). *For example, EMA has been variously called EA*, *EMA, environmental cost accounting (ECA), full cost accounting (FCA), total cost assessment (TCA), etc*" (IFAC, 2005, p. 17). This outlines the need to both clearly define the terms and concepts relevant for the purpose of the research (mainly ECA and FCA), and exclude those not used (e.g. Total Cost Assessment). This will be done further in the remaining sections of chapter 2.

Depending on the corporate needs, interests, goals, and resources, EMA can be applied at different scales, including the following:

- An individual process or group of processes e.g. production line;
- A system e.g. lighting, wastewater treatment, packaging;
- A product or product line;
- A facility, department, or all facilities at a single location;
- A regional or geographical group of department or facilities;
- A corporate division, affiliate, or the entire company.

EMA includes both information on material and energy flows (physical accounting), and information on environmental costs (monetary accounting).

The monetary side of EMA can be referred to as ECA, which "*focuses on the cost side of these* (environmental management) *activities in terms of both costs created and costs avoided*" (Rikhardsson, Benett, Bouma and Schaltegger, 2005, p. 46). Another way of looking at ECA is by referring to it as the generation, analysis, and use of monetarised environmentally related information in order to outline the money currently spent by an organisation on generating and managing pollution. It mostly covers private costs.

2.1.2.2 Environmental costs: definitions and classifications

Traditional management and cost accounting is a well established field, both within the academic world and the performance management activities conducted by companies. There is a quite broad consensus on costs classification.

Manufacturing costs have traditionally been split between fixed and variable costs:

- 'Fixed costs' do not change as the level of activity varies and consist of expenses that must be paid regardless of the number of units produced e.g. rent on equipment, salaries of permanent staff, some of the utilities, research and development, etc.;
- 'Variable costs' are those costs that change in proportion to the level of activity e.g. raw materials purchased, electricity consumed in the production process, etc.

In the long term, it is however considered most costs can be varied.

An alternative way of dividing manufacturing costs is between direct and indirect costs:

- 'Direct costs' are defined as those that can be easily and accurately traced to a cost object such as the production of a particular product or a specific process. They mainly include direct labour and material used in making the product.

- 'Indirect costs' (also referred to as 'overheads') are costs of an activity that are not easily associated with the production of specific goods or services. They include administration, engineering, real estate, insurance, research and development, etc. Indirect costs often represent a large proportion of the total costs and are usually allocated in proportion to either direct costs, or some physical resource utilisation. This can cause distortion in product-pricing and decision-making when the resources consumed during the production of individual products are not proportional to the volume of units produced or sold. However, the complexity and cost involved in implementing a more precise and accurate allocation of indirect costs is the usual cause for company using overheads for many non-direct costs.

Despite the terms of 'direct' and 'indirect' costs' now often replacing the variable/fixed terminology, in practice, the two approaches are to be seen as complement in getting a comprehensive understanding of the 'behaviour' of the different types of costs. For instance, the mixed concept of 'direct fixed expenses' defines those fixed costs that can be allocated to a product or process and would be avoided if the product was not manufactured or the process not used.

Examples of additional cost types worth mentioning include:

- 'Sunk costs', which are non-recoverable fixed costs i.e. costs that have been incurred in the past and cannot be changed by current actions. A good example is the upfront investment in research as well as intellectual property for the development of a given product. If the product is not successful in the marketplace, the costs associated with the product development cannot be covered.

- 'Opportunity costs', referring to the value of something given up to pursue something else; in other words the amount of the benefit sacrificed when the choice of one action prevents an alternative course of action. For example, if an asset such as capital is used for one purpose, the opportunity cost is the value of the next best purpose the asset could have been used for. Opportunity cost analysis is an important part of a company's decision-making, for instance when running comparative cost-benefit analysis. Any decision that involves a choice between two or more options has an opportunity cost;

- 'Contingent costs', which are costs related to a possible future event or condition or an unforeseen occurrence that may necessitate special measures. Contingency costs are usually used in project planning and costing to account for risk, but also in daily business to account for potential liabilities, such as the cost of having to pay for soil decontamination after an uncontrolled waste discharge or spillage.

Now when looking more specifically at environmental aspects, the classification of costs in the environmental management literature appears to be less developed, straight forward and standardised than what has been described above for traditional cost accounting. This is due to various factors, among which:

- The little number of years of practice in the field of environmental cost accounting compared to traditional cost accounting;

- The original confusion around the definition of EA and its subsets;

- The fact that the relevance and importance of various categories of environmental costs will clearly vary depending on the nature of the company.

Thus, there is no one definition of what constitutes an environmental cost or environmentally related expenditures. This also prevents defining a standard and systematic methodology to decide what, when and how to classify a cost as 'environmental'. Also, since most costs that can be related to environmental activities are shared with other activities (e.g. cleaning costs are usually part of the total costs for maintenance), they are mostly classified as indirect costs as they can be difficult to isolate and allocate. Depending on the cost systems at each company, environmental costs are usually shared between many different departments such as production, health and safety, quality, environment, and finances (e.g. insurances and taxes).

When reviewing available literature on environmental accounting, various classification methodologies were found for environmental costs, including:

- Direct, indirect, contingent, external and societal costs (Gale and Stokoe, 1997);

- Conventional, hidden, contingent, relationship/image, and societal/external costs (United States Environmental Protection Agency (US EPA), 1995, and Australian Chartered Accountants, 2001);

- Waste and emission treatment, prevention and environmental management, material purchase value of non-product output, and processing of non-product output costs (United Nations Division for Sustainable Development (UNDSD), 2001);

- Materials costs of product outputs, materials costs of non-product outputs, waste and emissions control costs, prevention and other environmental management costs, research and development costs related to environmental issues, less tangible costs (IFAC, 2005);

- Prevention, detection, internal failure, and external failure activities-related costs (Hansen and Mowen, 2005).

These variances can make it difficult for any given company wanting to engage in environmental accounting to decide how to do so in practice. Case studies of EMA implementation have been conducted over the past ten years, using one classification method or the other, which does not allow using results to draw comparisons and generalise conclusions across the different studies. One aspect of the literature on EMA noticed during the literature review is the almost constant publishing of new documents redefining concepts over and over with often little practical value added for the industry. Rather than making it easier for companies to understand how to implement EMA concepts, it gives the impression that it mostly remains a topic for discussions between academics pushing forward their views on the topic.

The 2005 IFAC International Guidance Document on EMA has a stated objective of resolving this issue by clarifying and standardising concepts, including the classification of environmental costs as per the third bullet point above and the more comprehensive table below. The different cost types listed can refer to either pollution control and/or prevention activities. This distinction will be further discussed in Section 2.2.

Table 1: Classification of environmental costs

1. Materials Costs of Product Outputs Includes the *purchase costs* of natural resources such as water and other materials that are converted into products, by-products and packaging.
2. Materials Costs of Non-Product Outputs Includes the *purchase (and sometimes processing) costs* of energy, water and other materials that become Non-Product Output (Waste and Emissions).
3. Waste and Emission Control Costs Includes costs for: *handling, treatment and disposal* of Waste and Emissions; *remediation and compensation* costs related to environmental damage; and any control-related *regulatory compliance* costs.
4. Prevention and Other Environmental Management Costs Includes the costs of *preventive environmental management activities* such as cleaner production projects. Also includes costs for *other environmental management activities* such as environmental planning and systems, environmental measurement, environmental communication and any other relevant activities.
5. Research and Development Costs Includes the costs for *Research and Development* projects related to environmental issues.
6. Less Tangible Costs Includes *both internal and external* costs related to less tangible issues. Examples include *liability, future regulations, productivity, company image, stakeholder relations and externalities.*

Source: IFAC, 2005, p. 38

The fact that this classification has been published under the name of the IFAC makes it likely to be acknowledged as the reference material in the area. However, a very similar standard had already been proposed a couple of years ago by the UNDSP in its guidance document, with little impact since then on the degree of implementation of EMA in the industry (except for one-off projects often financed by public authorities), and the development of a standardised approach when doing so.

In addition, this classification aims at generating a comprehensive statement of annual environmental costs (e.g. environmental balance sheet, pro-forma environmental financial statement, corporate environmental costs and revenues statement, etc.). As underlined in section 1.4, this is not the objective of the research, which means the IFAC and UNDSD classifications are not directly applicable given the scope of the project.

The application and interpretation of EMA and ECA principles for the purpose of the research and to the specific aspect of waste will be discussed in section 2.3, when defining waste accounting.

2.1.2.3 Methods and applications

Observations have been made on the failures of traditional accounting systems to define and track costs as close as they should. Some of these shortcomings are of particular relevance for the research work as they have a direct impact on the way environmental costs, and waste-related costs more specifically, are accounted for (or not) and managed (or not).

For instance, while fairly easily identifiable and attributable direct costs such as labour and raw materials are most often tracked and allocated to a particular product or process line, many indirect costs such as administrative, environmental, or health and safety costs, are allocated to the entire activities of the production site as overheads. Consistently with the definition of indirect costs, an overhead is "*any cost that, in a given cost accounting system, is not wholly attributed to a single process, system, product, or facility*" (US EPA, 1995, p. 19). In other words, the cost is shared across all activities not enabling to make anyone specifically accountable for it.

Environmental costs are most often hidden as overheads i.e. they are accounted for in central cost accounts (e.g. 'indirect production costs' or 'administrative costs') instead of being allocated directly to the product or process creating the cost. According to the IFAC, "*While overhead accounts are a convenient way to collect costs that may be difficult to assign directly to processes or products, this practice can create problems if a manager does not know where to look fot the needed cost information*" (IFAC, 2005, p. 27). In other words, the use of overheads can prevent optimal decision-making from being taken because appropriate cost information is not available. It might for instance be unclear which environmental costs are fixed (difficult to reduce) and which are variable (could be reduced by preventive environmental measures).

As underlined by the UNDSD, "*At a time when environmental compliance costs were marginal and profits high, this might have been reasonable. But with increased environmental awareness, strong competition and the need to improve production efficiency, especially wit regard to material efficiency, the cost of tracking and tracing material flows, throughout the company are by far outweighed by the improvement potentials identified and realized*" (UNDSD, 2001, p. 74).

Whether, as suggested in the last sentence, more complex cost allocation methods pays off in a systematic manner, will be discussed in Chapters 3 and 4. However, an important point that can already be made is that all companies should at least look into their environmental aspects, such as the generation of non-product outputs and energy consumption, to assess if they currently have a good understanding of how much those are costing them and whether it could make sense to adopt a different approach.

Many different accounting methods have been developed to overcome these shortcomings, including two of particular relevance for the research: FCA and Activity Based Costing (ABC).

As for the definition given in section 1.3, the main focus of FCA is to define and identify all costs that can be related to a given process, product, production site, project, etc. The figure below provides a schematic and simplified summary of the scope of FCA:

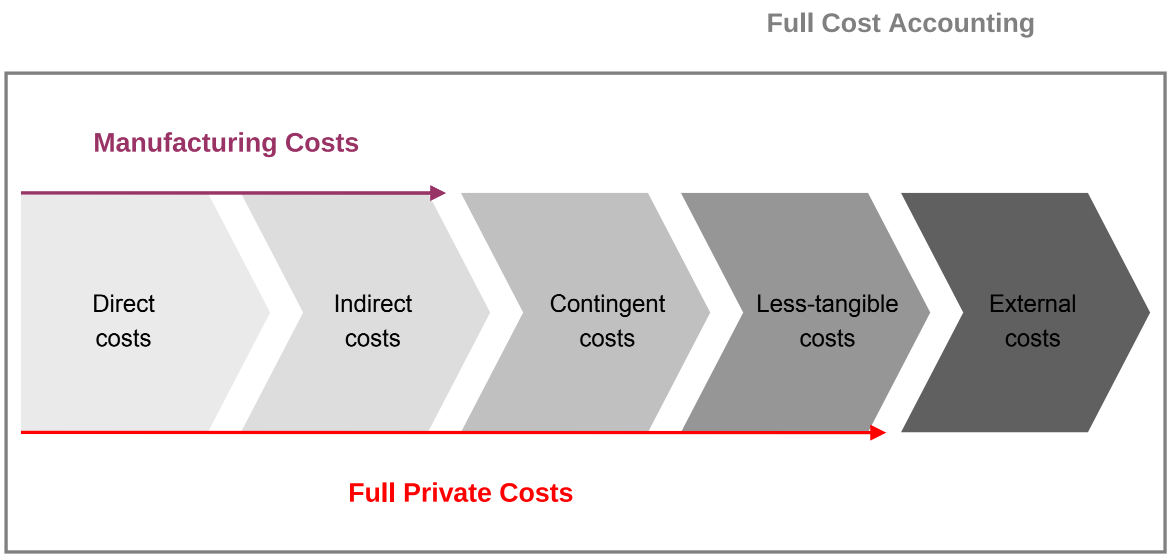

Figure 3: Moving towards FCA

Practical implementations of FCA for waste so far have mostly taken place in the field of public policy-making for municipal solid waste management. FCA can however also be used at the level of a private organisations to describe the process of determining all internal and external costs associated with a project, business entity, unit or process, and in the case of the research, an environmental aspect such as waste. However, since direct savings opportunities in reducing waste and process inefficiencies are to be identified by looking at those costs internal to the organisation, the research primarily focuses on costs 'private' to the organisation and FPCA, as defined in section 1.3.

Another well-known accounting methodology developed to tackle some of the flaws of traditional cost accounting is ABC. ABC tries to deal with the issue of cost misallocation, and focuses on private costs (both direct and indirect) as well as easily quantifiable contingency costs. ABC was first introduced in the early 1990s by Robin Cooper and Robert S. Kaplan, with the following starting assumption: "*Traditional cost systems use volume-driven allocation bases, such as direct labor dollars, machine hours, and sales dollars, to assign organizational expenses to individual products and customers. But many of the resources demands by individual products and customers are not proportional to the volume of units produced or sold. Thus conventional systems do not measure accurately the costs of resources used to design and produce products and to sell and deliver them to customers*" (Cooper and Kaplan, 1992).

Introducing ABC is expected to enable to link the costs of using resources and performing organisational activities traditionally accounted for as overheads (e.g. salaries, supplies, and rent) directly to the products and customers for which these activities are performed. A key aspect in doing so is the identification of cost drivers, which is often a very complex analysis. The first benefits from the ABC analysis and implementation are the restructuring and mapping of the organization's expenses from functional categories and departments to show how they related to the activities and business processes.

When applied as an environmental accounting tool, ABC "*improves internal company calculation by allocating costs typically found in overhead costs to the polluting activities and product. Significant material flows are traced throughout the company and their costs are allocated back to the polluting cost centres.*" (UNDSD, 2001, p. 14). The method of allocating overheads to specific cost drivers can be applied to waste costs, with the cost driver being a function of the production process that creates waste, units of product produced, or consumption of specific resources, that are most likely to end up as waste. On the contrary, the allocation of waste costs from a central overhead account will often misrepresent the cost of each particular process.

Both ABC and FCA aim to more accurately identify where environmental costs are being incurred as well as report their true value within the accounts. However, the specific and slightly different way in which the two concepts will be used for the purpose of the research is the following:

- FCA, and more specifically FPCA, will be used to describe the process of reviewing the current definition of waste costs at a given production site in order to identify, track and allocate previously hidden indirect costs (overheads) to the environmental aspect of waste;

- ABC will be referred to the allocation of waste costs back to a specific production process or step on the basis of a newly defined and more comprehensive definition of the full cost of industrial waste.

Looking at the potential uses of managerial environmental accounting, the EMARIC website provides a list of applications for EMA, which can also be used for FCA and ABC; these applications include product and process design, cost control and allocation, capital budgeting and investment planning, purchasing, supply chain management, product pricing, and performance evaluation (EMARIC, 2006). In all these different areas, the generation of monetary environmental information and its integration with more traditional cost information flows is expected, not only to be used as an input for environmental management decisions, but also for all types of routine management activities.

More generally speaking, environmental management and cost accounting is to be used as an instrument to promote cleaner production, which the United Nations (UN) refer to as a "*preventative approach to environmental management*", a "*mentality of how goods and services are produced with the minimum environmental impact under present technological and economic limits*", and a win-win strategy that "*protects the environment, the consumer and the worker while improving industrial efficiency, profitability, and competitiveness*" (UN Environmental Program production and Consumption Branch, 2001). Cost information is crucial, because if companies do not understand how much waste and pollution really cost them and how much money they lose every year due to inefficiencies, they cannot correctly estimate the value of potential Cleaner Production investments. Such projects aim at conserving raw materials, water and energy, eliminating toxic and dangerous raw materials, and reducing the quantity and toxicity of all emissions and wastes at source during the production process.

2.2 Industrial waste

In this section, background information on industrial waste will be provided. The link with cost and environmental accounting will then be made in Section 2.3, with the intention to give the reader an indication of the variety of potential costs that can be considered when trying to calculate the full cost of solid waste generated during the production process.

2.2.1 Production inputs and outputs

Input/output models, material tracking and mass balance tools are used to account for materials coming in and going out of a production process. They are part of 'physical-' or 'materials flow accounting': "*Under the physical accounting side of EMA an organization should try to track all physical inputs and ensure that no significant amounts of energy, water or other materials are unaccounted for. The accounting for all energy, water, materials and wastes flowing into and out of an organization is called a 'materials balance' sometimes also referred to as 'input-output balance', a 'mass balance' or an 'eco balance'*" (IFAC, 2005, p. 30).

The UNDSD (p.43) guidance document on EMA provides the following list of usual inputs to and outputs of a production process:

Table 2: Typical inputs to and outputs of a production process

INPUT in kg/kWh	OUTPUT in kg
Raw materials	**Product**
Auxiliary materials	Main Product
Packaging	By Products
Operating materials	**Waste**
Merchandise	Municipal waste
Energy	Recycled waste
Gas	Hazardous waste
Coal	**Waste Water**
Fuel Oil	Amount
Other Fuels	Heavy metals
District heat	COD
Renewables (Biomass, Wood)	BOD
Solar, Wind, Water	**Air-Emissions**
Externally produced electricity	CO2
Internally produced electricity	CO
Water	NOx
Municipal Water	SO2
Ground water	Dust
Spring water	FCKWs, NH4, VOCs
Rain/ Surface Water	Ozone depleting substances

Source: UNDSD, 2001, p. 43

The classification of inputs to the production process is quite straight forward. As per the table above, they consist mostly of raw and auxiliary materials, packaging materials, merchandise (products bought and resold with no or very little additional processing), operating materials (inputs that do not become part of any physical products delivered to customers such as office supplies, fuel for transport), and utilities (such as water and energy).

Looking at the various outputs of a production process, the situation appears to be a little more complex. In particular, what is to, and can be considered as waste or not is not as straight forward as what one could think.

2.2.2 Waste: definitions and interpretation

A few official definitions of waste can be given:

- The EU Council Directive 75/442/EES on waste as amended by Council Directive 91/156./EEC, Art.1(a) states that "*waste shall mean any substance or object in the categories set out in Annex I which the holder discards or intends or is required to discard*" (European Environmental Agency (EEA), 2006). The list of those categories is provided further down (cf. Table 3);

- According to the Organisation for Economic Cooperation and Development (OECD)/Eurostat Joint Questionnaire biennially send to all European countries, "W*aste refers to materials that are not prime products (i.e. products produced for the market) for which the generator has no further use for own purpose of production, transformation or consumption, and which he discards, or intends or is required to discard. Wastes may be generated during the extraction of raw materials during the processing of raw materials to intermediate and final products, during the consumption of final products, and during any other human activity*" (EEA, 2006). In addition, the OECD and Eurostat explicitly exclude "*residuals directly recycled or reused at the place of generation*" as well as "*waste materials that are directly discharged into ambient water or air*". By restricting waste to solid waste, the definition fits well with the research's focus. However, it includes life cycle aspects of waste generation (e.g. raw material extraction and product end of life), which goes beyond the scope of what is being looked at here;

- The 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal provides the following definition: "*Wastes are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law*" (EEA, 2006). This definition is specific to hazardous waste and relies on national legislations in the countries having ratified the Convention.

A common criterion to the three definitions to be used to decide when to consider an object or material as waste is that the holder has no further use of it and/or intends to discard it or has to do so by law. An additional input in deciding when to classify the material as waste is the list of sixteen categories of what is to be understood as waste, provided by the EU in its 'Framework Directive':

Table 3: Categories of waste according to the EU

Q1	Production or consumption residues not otherwise specified below
Q2	Off-specification products
Q3	Products whose date for appropriate use has expired
Q4	Materials spilled, lost or having undergone other mishap, including any materials, equipment, etc., contaminated as a result of the mishap
Q5	Materials contaminated or soiled as a result of planned actions (e.g. residues from cleaning operations, packing materials, containers, etc.)
Q6	Unusable parts (e.g. reject batteries, exhausted catalysts, etc.)
Q7	Substances which no longer perform satisfactorily (e.g. contaminated acids, contaminated solvents, exhausted tempering salts, etc.)
Q8	Residues of industrial processes (e.g. slags, still bottoms, etc.)
Q9	Residues from abatement processes (e.g. scrubber sludges, baghouse dusts, spent

	filters, etc.)
Q10	Machining/finishing residues (e.g. lathe turnings, mill scales, etc.)
Q11	Residues from raw materials extraction and processing (e.g. mining residues, oil field slops, etc.)
Q12	Adulterated materials (e.g. oils contaminated with PCBs, etc.)
Q13	Any materials, substances or products whose use has been banned by law
Q14	Products for which the holder has no further use (e.g. agricultural, household, office, commercial and shop discards, etc.)
Q15	Contaminated materials, substances or products resulting from remedial action with respect to land
Q16	Any materials, substances or products which are not contained in the above categories.

Source: Adapted from EEA, 2006

Once a material is considered to be waste, it is subject not only to the requirements and controls contained in the basic framework legislation of the Community on waste, namely the Waste Framework Directive, the Hazardous Waste Directive as well as the Waste Shipment Regulation, which implements the Basel Convention in the EU and deals with hazardous waste. It is also subject to a number of specific Community legislative instruments addressing particular treatment operations and waste streams.[6] These regulations will not be specifically covered as part of the research unless necessary.

Streams of industrial waste are typically divided between:

- So called 'common waste' streams such as wood, glass, paper, rubber, metals, textiles and leather, plastics, organic waste, etc.; and
- Hazardous waste streams (although the specific streams considered as hazardous will vary depending on the legislation in place in each country) such as used oils, batteries and accumulators, waste containing heavy metals, polychlorinated biphenyls (PCBs), sewage sludge in some cases, etc.

Now despite having provided what seems to be a clear and straightforward definition of what is waste, it will now be underlined that the boundaries between waste and non-waste are actually 'porous'.

2.2.3 Products, by-products, defects and process waste

Classifying solid outputs[7] of manufacturing is not as simple as simple as saying for instance that waste is 'anything that goes into a manufacturing process and does not come out as product'. Variances exist depending on whether the solid output is an in-specification product, a defective and out of specification semi-finished or finished products, a by-product, or process waste. The boundary between what is waste and what is product is not as clear as one

[6] Let's remind here that Swedish environmental legislation is, like in all other EU countries, mostly a transposition of EU regulations into national law. Thus EU legislation is considered as a good approximation for Swedish law.

[7] As per the classification, outputs from production also include non-solid items such as emissions to air and waste water. As per the defined scope of the research, these will, in principle, not be covered.

could instinctively think; there is room for interpretation. The following two examples of ambiguities or at least areas that can be subject to discussion:

- Should a by-product used by another industry as an input to its production never be considered as waste for the industry generating it?

- To what extent can a waste-to-energy process be considered as a use of a by-product or reuse of waste to produce an input (energy) to a production process, rather than just referring to the process as 'incineration'?

Now, given what has been said in the previous paragraph, there can be variances from one company to the other with regard to what will internally be considered as waste or not, which in turn will have an impact on how different costs will be defined and allocated; for instance deciding what will be included in the cost of non-quality rather than waste costs.

The following illustration can be used to clarify the approach taken for the purpose of the research:

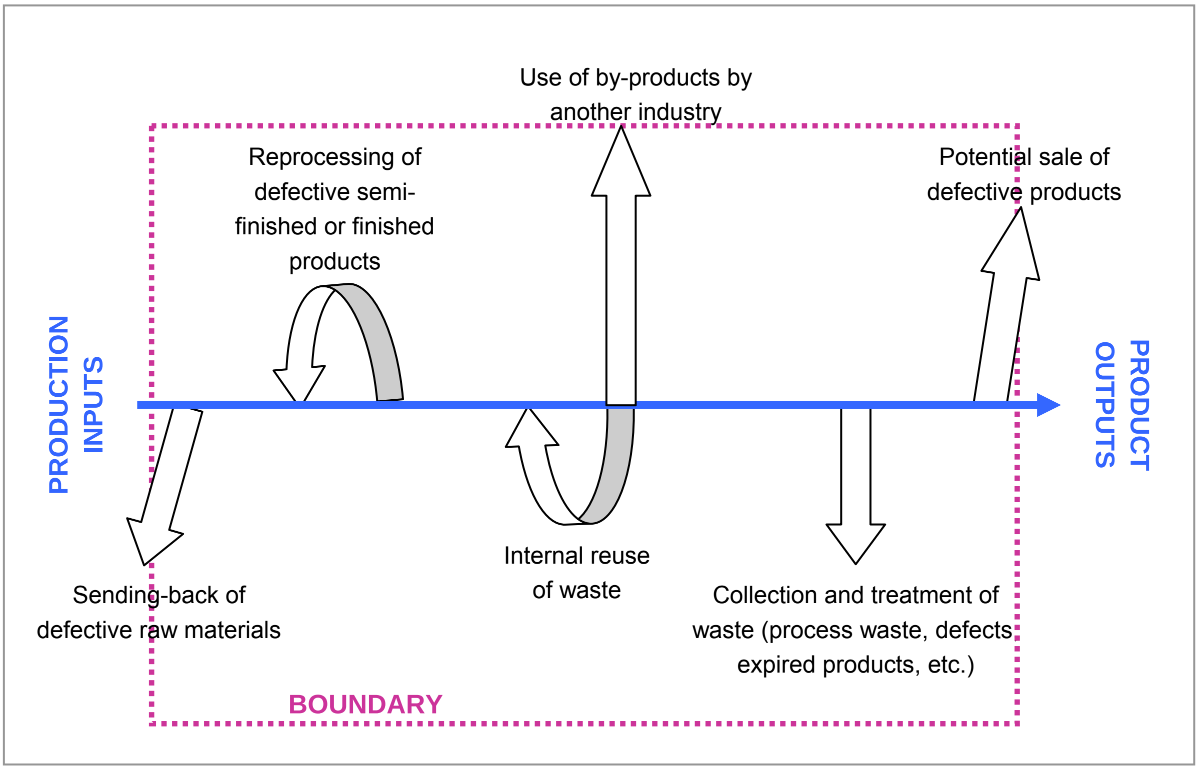

Figure 4: Potential boundaries for waste accounting

The definition given of waste as material that the generator has no further use for own purpose of production, transformation or consumption, and which he discards, or intends or is required to discard, was built upon to prepare the flow diagram along with the following considerations:

- Waste from the production process can be split between the process inputs not incorporated into the product (what is referred to as 'process waste'), and the process outputs that are not saleable (out of specification, defective or expired products);

- Defective raw materials do not usually end up as waste for the production site for two reasons: (1) quality controls often detect the non-conformance before the raw material is processed, and (2) procurement-contracts normally include an obligation for the supplier to take back and replace defective raw materials at his cost. However, in a situation when raw materials come from far away, it might not be worth sending them back if defective, which means they could become waste for the factory. This is one of the reasons why the inclusion or exclusion of defective raw materials in the total cost of waste has to be viewed on a case by case basis.

- Those semi-finished defect products and process wastes that are being reused internally as an input to the production process are usually not considered as waste since they are not being discarded or intended to be, and also enables to avoid having to source new materials. However, whether they should be included when trying to calculate the total cost of waste can be discussed for the following reason: process waste and defects can, even if reused, still be the result of process inefficiencies that could maybe be avoided through waste minimisation and quality optimisation programs. This in turn would reduce the associated internal costs of producing, managing and reprocessing waste and defects. The approach chosen is to view on a case by case basis whether such aspects are to be covered as part of the full cost of waste, also depending on the costing system in place for poor-quality;

- According to the EEA definition, a by-product is "*A useful and marketable product or service deriving from a manufacturing process that is not the primary product or service being produced*" (EEA, 2006). So in theory, a by-product is never to be considered as waste, since it neither can be part of the product, nor will be discarded. Again, it could be argued that by-products can sometimes be a signal indicating process inefficiencies; but because they often generate revenues and allow saving resources, they appear to be both financially and environmentally interesting to promote. Arguing these considerations could be the topic of a dedicated project and cost modelling, and is only relevant to discuss on a case by case basis. The research will therefore disregard by-products, unless the company has been unable to find a user/buyer for them, meaning that they end up as waste;

- Defects that are saleable, but at a lower price and/or for another application are usually included by companies as part of the total cost of non-quality. However, it should be outlined that saleable defects or out of specification products often have a probability of ending up as waste if no buyer is found. Such probability will increase if the transaction costs incurred in looking for and finding potential buyers are important. As a result, and depending on the value of the defect products, as well as the cost involved in its disposal, the production site will have a more or less strong incentive to decide to treat those defects as waste. This again, underlines the frequent overlap between quality and waste costs.

A good way to summarise the points made above is to point out that there is a great variety of factors that can participate in waste generation. The existence of waste within a manufacturing process may indicate inefficiencies within the production process, technical problems in particular machinery, management systems inefficiencies, human error or lack of knowledge/training relating to operational and maintenance procedures, raw materials and product quality issues, etc. Because of the frequent overlap between quality and waste issues, the inclusion or exclusion of costs of poor-quality in waste accounting has to be viewed on a case by case basis. There is actually no need to be dogmatic about the internal definition of waste costs at a given company or production site. Depending on whether the objective is to reduce waste as such, or manufacturing inefficiencies as a whole will be the main driver in making these choices, given that waste and poor-quality costs can be added up to provide a total cost of process inefficiencies.

Before providing some insight in Section 2.3 to what waste accounting could look like, additional background information on waste management solutions and strategies will now be provided.

2.2.4 Industrial waste collection, treatment and management solutions

The various actors dealing physically with waste, playing a role in the financial flows involved, and/or having an impact on the cost of waste for the industry mainly include:

- Waste producing industrial companies themselves;
- Private waste management companies (collectors, recyclers, scrappers, etc.);
- Municipal waste management companies, including landfilling and incineration facilities;
- In Sweden, the central State has so far decided to retain the monopoly for the treatment, incineration and landfilling of the most hazardous waste streams at a publicly owned installation called SAKAB[8];
- National, regional and municipal public administrative authorities giving out environmental permits and conducting inspections;
- Industries that are users or even sometimes buyers of the 'waste' generated by a site, whether process waste, by-product or defect products.

There are obviously many more stakeholders not directly involved in the management of industrial waste, that could be considered as they have strong interests and potential influence, such as the local community and the media (especially relevant for companies running the risks of contaminating the area around due to the hazardousness of the waste they generate).

Now, when viewing the different possibilities for waste management, a wide range of combinations of solutions are possible. Some are choices that production sites can make, while others are forced upon them depending mostly on the legislation in place, but also on the structure of the market for waste and the availability of local waste treatment infrastructure:

- On site treatment versus contracting: For some large scale production sites, it can be economically interesting to have their own treatment equipment, such as a waste water treatment plant, an incinerator (with the potential benefit of internal energy recovery) or a private landfill. However, in addition to checking their economic viability, the right to have such private waste treatment facilities is always subject to the approval and official permission of public authorities;

[8] SAKAB is a public organisation that has the monopoly for the management of some of the most hazardous waste produced in Sweden; refer to SAKAB's homepage for more information at: http://www.sakab.se/templates/Page.aspx?id=117

- Source separation vs. mixed waste: waste can either be separated at the production site by the workers and placed in different containers, or be collected by the waste contractor as mixed waste. Many companies have already engaged in source separation in order to minimise costs (mixed waste collection is usually more expensive), as well as recover some money from separated valuable recyclables such as metal scrap and some plastics, for which the waste generating company/site sometimes gets paid;

- Looking at what happens to waste after its collection, the various options are: waste reuse, material recycling, incineration with eventual energy recovery, and disposal/landfilling. Where the different streams of waste will eventually end up depends on many different factors including legislation (e.g. it is now forbidden to landfill biodegradable waste within the EU), the treatment and recycling facilities available (or not) and the subsequent financial incentive given by municipal and private waste collection and management companies, the potential for some of the waste to be reused internally or by another industry as a by-product, etc.

The combination of these different options will define the waste management situation for a given site, with a direct impact on how much money will be spent on waste. Overall, it can be assumed that waste collection and treatment remains by far a cash-cost for a most sites despite some specific streams (metal scrap, organic by-products, valuable plastics etc.) having the potential to generate positive financial flows that have to be accounted for when assessing the net cost of generating waste.

So far, waste has only been considered once already generated, but the most desirable option from an environmental perspective is to prevent its production, which most often would also turn out to be the most interesting option for a site from an economical point of view.

2.2.5 Waste minimisation and prevention

The well-known waste management pyramid presents the different waste management options ranging from the most to the least desirable from an environmental perspective:

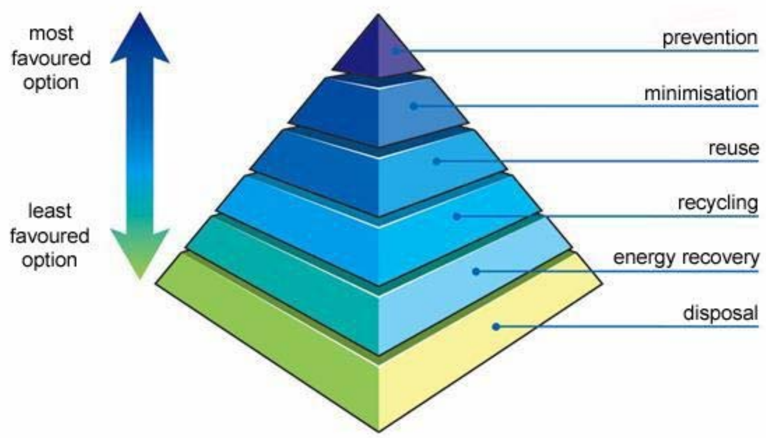

Figure 5: Waste hierarchy pyramid
Source: Wasteonline, 2006

According to the US EPA, waste reduction practices include "*source reduction, recycling and reuse, and treatment of waste constituents. Waste reduction minimizes the amount of waste that needs to be disposed of in the first place, and limits the environmental impact of those wastes that actually are disposed.*" (US EPA, 2006). Waste minimisation is an activity that relates to all inputs and outputs from an industry, business, site or process; it can be applied to process and business operations such as utility use, raw materials, consumables, packaging, liquid and solid wastes, air emissions, etc. Waste is not simply materials excess to requirements, but also represents a loss in profits for the organisation, which is the approach the research work intends to push forward via the use of cost accounting as a driver for industrial waste.

The OECD also provides some definitions and categorisation of waste minimisation and prevention strategies. As per the table below, which can be easily linked back to the waste pyramid, minimisation is a broader term than prevention; waste prevention covers prevention, reduction at source and reuse of products; waste minimisation however also includes quality improvements and recycling.

Preventive Measures			**Waste Management Measures**			
Prevention	Reduction at source	Re-use of products	Quality improvements	Recycling	Energy recovery	Pre-treatment
Waste Minimisation						

Figure 6: OECD definition of waste prevention and waste minimisation
Source: European Commission Environment Directorate General, 2003, p. 15

Definitions and classifications given should not be considered as definitive, especially as they are being argued upon in practice. For instance, there is some lobbying going on at the EU level to try and bring energy recovery at the same level as material recovery (recycling). However, this has no impact on the fact that cleaner production, when applied to industrial waste excludes disposal, off-site recycling, pollution treatment, and end-of pipe control, which all are to remain second best options for a site/company, after viewing and assessing the technological feasibility and economical viability of prevention measures and investments.

Now, making the most appropriate decisions between the different waste prevention, minimisation and management options available will not be possible if the current costs of waste are not defined, measured, accounted for and reported properly. The following section provides some background on the types of costs that can potentially be included when trying to understand how much money is really being spent on waste, beyond looking only at the money paid to waste contractors for waste collection ad treatment.

2.3 Cost accounting for industrial waste

2.3.1 Waste accounting in the literature

There is little literature available on the specific topic of costs associated with the generation of waste in the production process. A definition of waste accounting was however found, as the "*financial information to support waste minimisation programs and to monitor and improve efficiencies in producing goods and services*" (Monash University Centre for Environmental Management, 1997). This definition covers both:

- The aspect of generating less waste to be treated or disposed of; and
- The more 'internal performance orientated' way of looking at waste as the result of inefficiencies in the manufacturing process.

The necessity of looking at waste costs in a dual manner has also been underlined by the UNDSD in its 2001 guidance document on EMA: "*For internal company calculation of environmental costs, expenditure for environmental protection is only one side of the coin. The costs of waste and emissions include much more than the respective pollution prevention or treatment facilities (…). The concept of waste has a double meaning. Waste is a material which has been purchased and paid for but which has not been turned into a marketable product. Waste is therefore indicative of production inefficiency. Thus the costs of wasted materials, capital and labour have to be added to arrive at total corporate environmental costs and a sound basis for further calculations and decisions*" (UNDSD, 2001, p. 12). This first step in expanding the definition of waste costs is summarised by the figure below:

	Environmental protection costs (Emission treatment and pollution prevention)
+	Cost of wasted material
+	Cost of wasted capital and labour
=	Total corporate environmental costs

Figure 7: An extended definition of waste costs
Source: UNDSD, 2001, p. 12

Residual Waste Accounting (RWA) is a method, which "*not only measures the costs of waste by their disposal costs, but also adds the material purchase values and pro rata production costs*" (UNDSD, 2001, p. 14). In addition to wasted raw materials, the inclusion of such "*pro rata production costs*" is of interest because it allows to include the value added that all wastes have had added to them during production processes. In moving towards understanding the full cost of waste, it is important to know how much value has been added to it prior to collection, treatment and/or disposal. As a result, potential increased material and production efficiencies achieved thanks to waste reduction/prevention can be included in decision-making.

What is being underlined is that companies typically know about the cash-cost of waste (usually equal to the price charged by external waste contractors and eventual green taxes), when actual waste-related prodction costs can be significantly more. Hence, if calculated properly, total waste costs would account for a surprisingly large proportion of the total costs of many businesses:

- Company projects in Austria and Germany have shown that the cash-cost of waste disposal typically represents 1% to 10% of total environmental costs, while the purchase costs of wasted raw materials represent 40% to 90%, depending on the industry and type of company considered (UNDSD, 2001, p. 12);
- According to Envirowise, a free governmental environmental consultancy in the United Kingdom, "*the true cost of wasted materials is typically between 5 and 20 times the waste disposal costs*" (Envirowise, 2003, p. 11).

However, in both those examples, the information was not presented in the way that would motivate most companies to engage in more complex cost accounting for waste. An alternative would be to express newly defined waste costs (using RWA) as a share of total production costs, but in order to convince managers, what would need to be assessed is the impact of an expanded definition of waste costs on the operating margin.

Looking beyond RWA, and on the basis of its classification of environmental costs, the IFAC provides a list of more specific examples of what could be included when calculating total environmental costs; all environmental aspects are covered including waste, as per the table below.

ENVIRONMENTAL DOMAINS ENVIRONMENT-RELATED COST CATEGORIES	Air & Climate	Waste Water	Waste	Soil, Groundwatera	Noise and Vibration	Biodiversity and Landscape	Radiation	Other	Total
1. MATERIALS COSTS OF PRODUCT OUTPUTS									
• Raw and Auxiliary Materials									
• Packaging Materials									
• Water									
2. MATERIALS COSTS OF NON-PRODUCT OUTPUTS									
• Raw and Auxiliary Materials									
• Packaging Materials									
• Operating Materials									
• Water									
• Energy									
• Processing Costs									
3. WASTE and EMISSION CONTROL COSTS									
• Equipment Depreciation									
• Operating Materials									
• Water and Energy									
• Internal Personnel									
• External Services									
• Fees, Taxes and Permits									
• Fines									
• Insurance									
• Remediation and Compensation									
4. PREVENTIVE and OTHER ENVIRONMENTAL MANAGEMENT COSTS									
• Equipment Depreciation									
• Operating Materials, Water, Energy									
• Internal Personnel									
• External Services									
• Other									
5. RESEARCH and DEVELOPMENT COSTS									
6. LESS TANGIBLE COSTS									

Figure 8: Distribution of environment-related costs by environmental domain
Source: IFAC, 2005, p. 55

A similar table can be found on page 19 of the UNDSD guidance document; the cost categories are however partly different, which once again points out the potential confusion one can be faced with if wanting to apply standard EMA methods as presented by their developers. Moreover and as already pointed out, such a listing and way of presenting the information is aimed at producing yearly environmental accounts, which makes the direct use of this methodology inappropriate for the purpose of the research.

Thus, waste-specific alternative cost models were looked for, but with little success, especially as the ones found were both slightly out of date and not from primary academic/scientific sources:

- One was found on the website of Cleaner Production International LLC, an international consultancy in the field of sustainable business. An article was published in 1998, proposing a calculation method for a more comprehensive approach of waste-related costs. It consists of adding (1) Inefficient use of raw materials leading to waste, (2) Waste handling prior to treatment or disposal, (3) Waste treatment, (4) Waste disposal, as well as (5) Other items such as higher insurance premiums (Cleaner Production International, 1998).[9] The main purpose of the methodology proposed is to provide a more comprehensive figure for the current cost of pollution and specifically waste, to be used by decision-makers in pollution prevention capital budgeting and investment planning.

- Environment Victoria (the environmental agency of Australia' state of Victoria), in association with EcoRecycle Victoria (a publicly funded organisation in the same state, now called 'Sustainability Victoria') has, in 2001, prepared a guide for local industries to explain the benefits of engaging in FCA for waste generated during the production process i.e. increase productivity and reduce costs. The main aspects to be reviewed when calculating the full cost of waste are: (1) Waste management contract and administration costs, (2) Costs of raw materials in the waste product, (3) Depreciation of processing equipment generating waste, (4) Depreciation of waste management equipment, (5) Energy used in the production of waste, (6) Water used in the production and cleaning of waste, (7) Materials inventory and warehousing costs, (8) Loss staff time, (9) Occupational health and safety equipment and training, (10) Compliance monitoring costs, (11) Potential liability costs, (12) Reduced employee morale, etc. It was estimated by Environment Victoria and Ecorecycle that "*the full costs of manufacturing waste are typically at least 5 to 10 times higher than the waste disposal costs*". The following catch-phrases is even used: "*for every dollar your organisation spends to dispose of waste, you lose at least another four to nine dollars on items such as wasted materials, staff time, energy, fuel, water use, storage space and equipment depreciation*" (Ecorecycle, 2001, p. 1).

For the purpose of the interviews conducted with 16 Swedish companies during the month of June, a draft structure of waste-related costs had to be prepared at an early stage of the project. It was mostly based on the information presented above as well as personal input, and was to be used as a reference point when discussing with the interviewees the current definition of waste costs used at their sites, as well as the potential interest in including additional categories of waste-related costs in the future.

2.3.2 An initial draft classification of waste-related costs

The structure and examples of waste-related costs presented below was prepared before starting conducting interviews early June. To avoid confusing the interviewees, the cost classification used during the interviews was a simplified version of the one presented below.

[9] Examples of costs included in each category as well as details about the calculation method itself can be found on their website at: (http://cleanerproduction.com/Pubs/pubs/MgtAcctgandP2.html).

An initial comment that can be made is that the degree of difficulty to specifically define and track costs increases when going down the cost categories listed i.e. when moving towards FCA. In the case of risk-related and less tangible costs, it can even be quite hard if not impossible to provide a reliable figure.

It is also important to outline that the listing below is neither a complete list, nor a definitive classification of waste-related costs. It aims at giving an indication of the variety of cost types that can potentially be included when trying to account for the full cost of waste generated during the manufacturing process. Because production costs, indirect costs in particular, are defined in different ways in different companies, various departments will be the 'owners' of part of the data needed, mainly financial and accounting, health and safety, quality, environment, production.

Table 4: Categories and examples of waste-related costs

Cost Category	Example of potential costs
Cash costs	Waste disposal costs: price paid to different waste contractors for services rendered (rent of containers for sorting, waste collection, transportation and treatment) Green taxes paid to authorities (landfill tax, tax on the use of hazardous substances and the generation of hazardous waste, etc.)
Direct and indirect production costs	Cost of wasted materials: purchase price of the quantity of raw material wasted (e.g. rubber, metals, food ingredients) including storage, inventory, warehousing and handling costs before usage of the materials, replacement cost of raw materials wasted that have to be bought again Production costs up to the time the material, semi-finished or defect product becomes waste (mainly labour, energy, water) Other production costs (most often overheads) such as depreciation of extra production capacity necessary to accommodate waste generation, maintenance, etc Administrative environmental overheads such as regulatory costs (permitting and inspection by authorities), voluntary costs (EMS, training, etc.), office work time spent on waste (data gathering, reporting, etc), etc Cost of waste handling prior to treatment or disposal e.g. labour, supplies, depreciation of cost of drains, safety equipment and storage, waste storage costs, etc. Waste treatment and processing costs e.g. labour, energy and electricity, maintenance, chemicals, depreciation of waste management equipment, taxes on rent of and space for treatment systems, etc.
Contingent costs	Fines and penalties (although they could be included in the cash-cost) Risk and liability costs (potential clean up and remediation costs in case of contamination) Higher insurance premiums due to the use of hazardous materials and the generation of hazardous waste Risk of work-related accidents and associated costs (occupational health and safety);
Less tangible costs	Relationship costs and cost of damaged image (media, public, community, ethical rating agencies, etc.)

	Cost of future more stringent legislation Decreased workers morale and motivation, increased illnesses, etc
External costs	Resource depletion, greenhouse/climate change impact, ozone depletion, local air/water quality impact, noise pollution, etc

An additional and complementary category of costs that could be viewed is the 'opportunity cost' of generating waste, as per the definition given in section 2.1.2.2 page 16. Waste-related opportunity costs can be viewed in many different ways such as accounting for the lost sales (i.e. the sales value of waste if it had been a product output instead), or the money spent on waste that could have been invested in productive and value-adding activities.

Building on the above-described classification, Figure 9 below summarises the types of costs that can be allocated to waste generated during the manufacturing process:

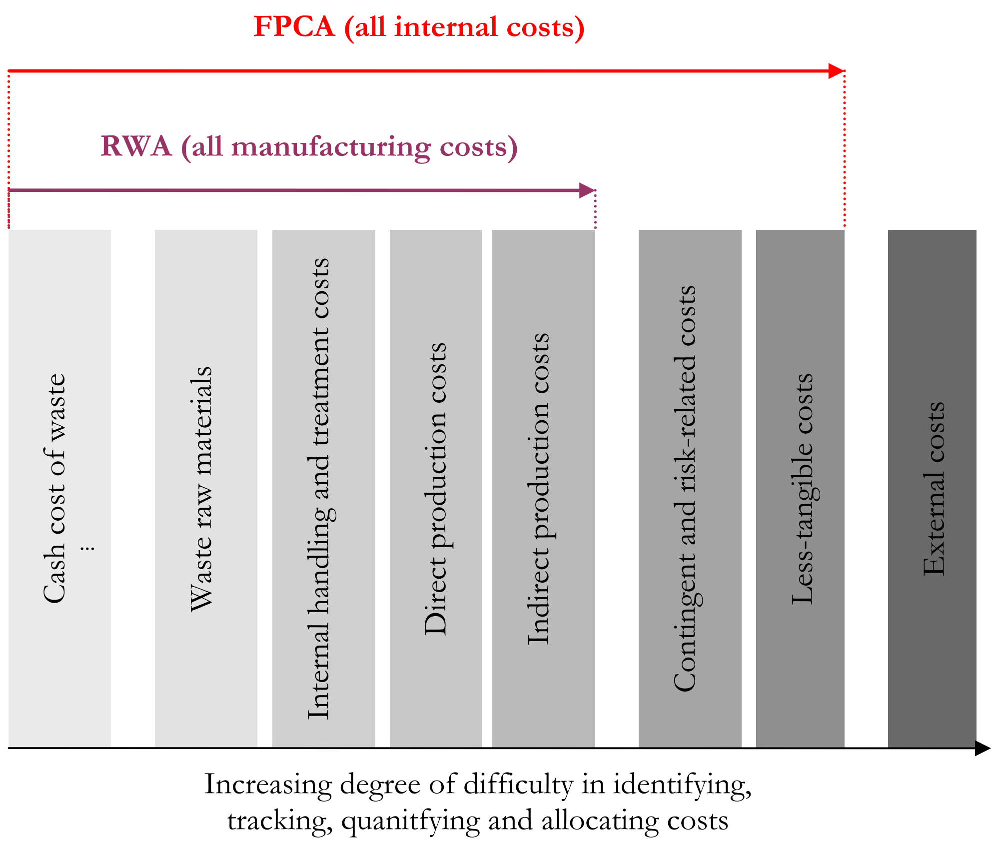

Figure 9: Draft modelling of FCA for waste-related costs

Manufacturing costs are very likely to be the cost categories companies will be the most interested in looking into as they have a direct impact on their economic bottom line. Additional cost types leading towards FPCA and FCA being less obvious and more difficult to quantify, RWA can therefore be expected to be the conceptual tool with the most potential for practical implementation within the industry. However, from a purely environmental point of view, it should be pointed out that the narrower the definition of waste costs the less effective the new accounting will be at moving towards long-term sustainability e.g. if future and/or societal costs are not included.

3 Assessing the relevancy of waste cost accounting

Chapter 3 is divided in three sections:

- Section 3.1 provides an overview of benefits, drivers, as well as existing and potential barriers to the implementation of EMA and affiliated ABC and FCA;

- Section 3.2 consists of a summary and analysis of the empirical study conducted with twenty companies/production sites;

- In Section 3.3, theoretical and empirical results are confronted to design a draft approach to be used when trying to start implementing waste accounting at a given site or company, with the objective of partially testing this methodology with the case study company (Chapter 4).

3.1 Drivers and barriers for EMA in the literature

The latest book published on EMA is a gathering of articles published under the umbrella work of the EMARIC, and aims at providing an overview of the status and challenges in implementing EMA. The full reference is:

Implementing Environmental Management Accounting: Status and Challenges. Pall M. Rikhardsson , Martin Benett, Jan Jaap Bouma and Stafn Schaltegger. Dortrecht: Springer, 2005

The introduction chapter consists of a discussion paper analysing whether EMA should be considered as a real innovation or just '*another management fad*', based on management and innovation theories (e.g. isomorphism, innovation diffusion curves, etc.). Leaving aside the conclusions drawn by the authors, the fact that the same people who originally developed EMA, are now discussing its real potential to be a widely and successfully used as a management tool, indicates that they might start acknowledging the obvious gap between theoretical concepts and their workability for the industry.

Hence, more than ten years have gone by since the first developments in the field of environmental accounting as a business management tool. Known examples of implementation and continuous use of EMA over time by the industry are scarce, despite many case studies conducted by practioners around the world. Fully understanding the reasons why EMA is used or not in practice is outside the scope of the research. However, an overview of expeted benefits, drivers as well as existing and potential barriers will be provided in this section. This information will be partially used as an input when drafting an approach to assess the need for a given company or production site to engage in waste accounting.

3.1.1 Expected benefits

The drivers behind why an organisation might consider undertaking a more complex cost accounting in general include a mix of external and internal environmental and financial pressures. For waste accounting specifically, these could include increasing community, government and market expectations as to how a business manages its environmental impacts, as well as an organisation seeking new opportunities to improve production efficiency and reduce costs. Generally speaking, implementing more advanced cost accounting principles to better manage environmental aspects of a business should be expected to achieve reduction of both environmental costs and impacts, as per the flow chart below:

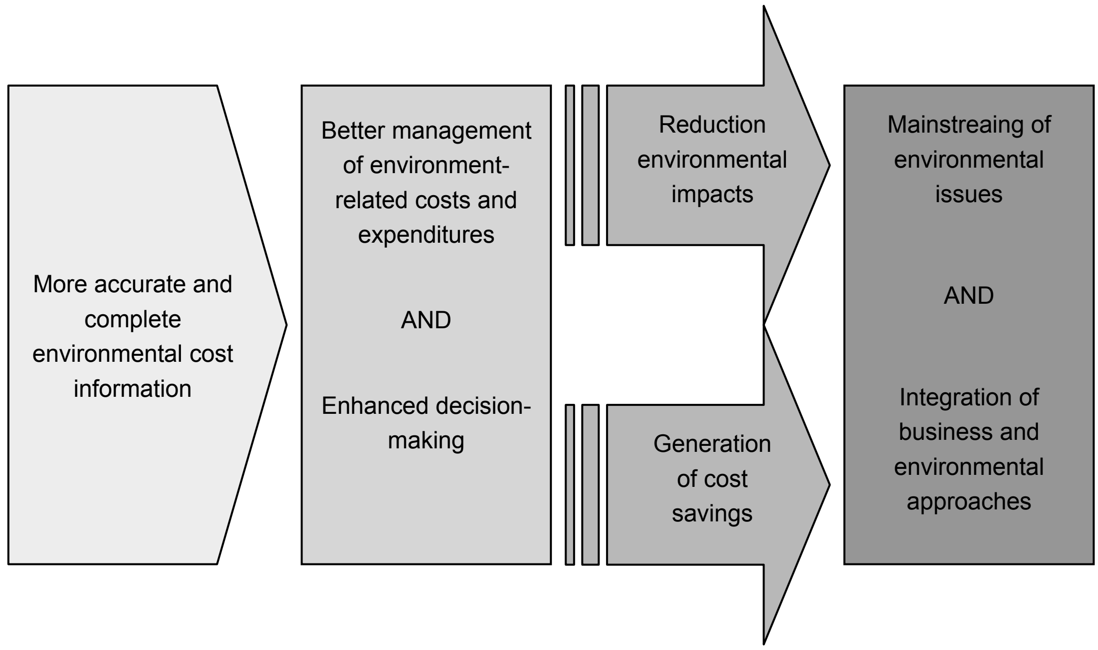

Figure 10: EMA benefits flowchart

The table below summarises the more detailed expected benefits to be derived from embracing EMA, as outlined by its developers and practioners. The three main information sources used were:

- The EMARIC website, which aims at "*coordinating, promoting, researching and educating in the field of EMA*", and therefore at "*promoting the integration of environmental cost information and materials and energy flow information into routine management decision-making, as a support for improved environmental performance*" (EMARIC, 2006);
- The IFAC guidance document already mentioned in the first two chapters;
- A chapter of the book *Implementing Environmental Management Accounting: Status and Challenges* written by Roger Burrit and entitled 'Challenges for Environmental Managemenrt Accounting'.

Table 5: Summary of expected benfits of EMA

EMARIC (EMARIC, 2006)	**IFAC** (IFAC, 2005, p. 24)	**Burrit** (Burrit, 2005, p. 26)
(1) Track and manage more accurately the use and flows of energy and materials, including waste volumes, types, and fate (2) Identify, estimate, allocate, and manage costs more accurately as well as reduce them, particularly environmental types of	(1) Enhance compliance: Support environmental protection via cost-efficient compliance with environmental regulation and self-imposed environmental policies (2) Improve eco-efficiency:	(1) Identify cost reductions and improvements (2) Prioritise

costs (3) Provide more accurate and comprehensive information to support the establishment of and participation in voluntary, cost-effective programs to improve environmental performance (4) Provide more accurate and comprehensive information for the measurement and reporting of environmental performance (5) Improve company image with stakeholders such as customers, local communities, employees, government, and finance providers	Support the simultaneous reduction of costs and environmental impacts via more efficient use of energy, water and materials in internal operations and final products (3) Enhance strategic positioning: Support the evaluation and implementation of cost-effective and environmentally sensitive programmes for ensuring an organisation's long-term strategic position	environmental actions (3) Guide product pricing mix and development decisions (4) Enhance customer value (5) Future-proof of investment and other decisions with long term consequences (6) Assess the eco-efficiency and/or sustainability of a company's activities

As per the table above, literature on EMA outlines many different potential uses. It is for practical reasons however unlikely that a company would integrate EMA in all aspects of its business. Applications of relevance for a given company or site have to assessed on the basis of identified or likely specific benefits to be derived in a specific aspect of the business (e.g. investment appraisal, product-pricing, waste management, etc.) and/or department (purchasing, production management, supply chain management, etc.).

Looking more specifically at waste management and based on the list of expected benefits listed above, the use of EMA/ABC can be expected to provide the following advantages:

- Responsibility and accountability for waste costs can be given to those who have direct control over the production processes generating waste;

- Activities and processes leading to high waste levels can be identified, optimised, and even sometimes avoided.

Thus, implementing enhanced cost accounting procedures is expected to provide better information and visibility on waste issues, and in return, highlight the economic and environmental irrationality of some of the organisation's current waste management practices.

3.1.2 Drivers and success factors

In this sub-section, drivers and success factors to the implementation of EMA, ABC and FCA will be given in the form of bullet points. Each point could be discussed in length, and a more thorough review would actually imply being more cautious and partly differentiating factors for each of the three accounting methods referred to. However, all three are based on similar assumptions and have similar goals as well as potential benefits. Thus, the common factors listed below provide the level of detail needed for the purpose of the research, which, as already underlined, focuses on what companies are and could be doing in the area of waste accounting, rather than testing theoritical concepts that appear to have limitations preventing them from being widely implemented.

The list of factors is therefore not extensive. It summarises some of the information found in the different literature sources reviewed e.g. the 2001 UNDSD and 2005 IFAC guidance documents on EMA, the 2005 EMARIC book on EMA implementation mentioned above, the 1995 US EPA introductory guide to environmental accounting for management purposes, as well as more traditional management literature on cost accounting and ABC.

Table 6: Some driving forces and success factors for EMA, ABC an FCA

Factors related to the company and the industry	Factors related to the accounting system and cost situation/structure	So-called 'soft factors'
(1) Size of the company (2) Diversity and complexity of product lines and operations (3) Probability of revealing cost saving opportunities	(1) Amounts and proportion overheads (2) Amounts and proportion of environmental costs (3) Complexity and multiplicity of cost drivers making allocation difficult	(1) Clarity of specific goals to be achieved (2) Readiness to change (3) Level of management commitment (4) Existence of a so-called 'project champion'

A few comments can be made:

- The company and the industry: The literature outlines that larger companies with complex production processes will derive more benefits from an improved environmental accounting system, simply because the likelihood of revealing cost savings opportunities is expected to be higher than for SMEs with more straight forwards manufacturing operations. This can be argued, as it is likely that many 'low-hanging' fruits can be picked up at smaller businesses using simple EMA principles (e.g. accounting for wasted materials), while any changes to the accounting and information system in place at a large company would be made more difficult by the complexity of implementing it in practice. Smaller organisations are often more flexible and are usually characterised by a lower degree of resistance to change.

- The cost situation and accounting system: Logically, the higher the amount of environmental costs hidden as overheads, the higher the potential to uncover potential areas for improvement.[10] According to EMA principles, where environmental costs form a significant part of the total operating costs an attempt should be made to separate them from general overheads to trace and allocate them to environmental aspects such as waste. However, this argument can be hard to use in practice, as most companies do not have a precise idea whether their environmental costs are high or not, since they do not account for them separately. Thus, an initial assessment needs to be run. It is likely to be more objective if done by someone external to the company, able to look at the situation with less preconceived ideas.

[10] Some case studies have tried to determine the percentage of overheads required to make EMA relevant , but it is not believed the results can be transferred. It is believed a case by case assessment should be run.

- Soft-factors: Even if organisational theory is not included in the scope of the research, soft factors cannot be ignored because they will play a major facilitating or hindering role in the implementation of the recommended changes. Hence, a positive attitude towards new working procedures and methods will greatly facilitate the success of waste accounting in practice. Promoting readiness to change within the organisation can be driven by the openly expressed commitment of the management to support the project, preferably backed-up by clear goals and identified benefits to be achieved. Management commitment is actually essential to the success of any business project. This is especially true of cleaner production, which is an ongoing process and requires a dedication over years to track down and eliminate waste, using cost accounting among others. If staff members cannot sense such commitment, then the improvement plans developed will never be implemented and it will all have been a waste of resources and efforts.

3.1.3 Barriers and challenges

The literature on EMA also provides information on the identified barriers to its implementation. The table below is a brief summary of such challenges:

Table 7: Current identified barriers and drawbacks to the implementation of EMA

Limitations of conventional management accounting (IFAC, 2005, pp. 26-28)	**Lack of recognition of environmental impact in management accounting** (Burrit, 2005, pp. 27-30)	**Academic and practical challenges for EMA implementation** (Burrit, 2005, pp. 32-39)
(1) Communication links between accounting and other departments are not well developed (2) Environment-related costs are often hidden in overhead accounts (3) Materials use, flow and cost information are often not tracked adequately (4) Many types of environment-related information are not found in the accouting records	(1) Environmental costs are assumed not to be important (2) Certain types of environmental costs are not identitified or tracked (3) Indirect environmental costs are included in general business overheads (4) Investment appraisal usually excludes environmental considerations (5) Little accounting for externalities and sustainability issues is conducted	(1) Empirical research is scarce and focused on describing the current state of implementation rather than analysing or evaluating effectiveness (2) SMEs and enterprises in developing countries are currently not being taken into account (3) EMA literature and case studies look for win-win outcomes without considering cases when EMA is a net cost to the business (3) Reliable and affordable software systems supporting EMA are not well developed

Additional potential challenges can be outlined:

- Lack of consistency in management accounting practices: While financial accounting is conducted on the basis of a set of accepted accounting as well as external auditing principles, internal managerial and cost accounting is not. Thus, generalising specific methodologies can prove to be difficult.

- Traditional cost allocation of indirect costs can be a difficult and ambiguous process, especially as there are no cost accounting prescriptive methods. Thus, separation of a common indirect cost (e.g. depreciation of integrated production technology) into an environmental element such as waste will often be, at least partly, an arbitrary decision that people are likely to argue about;

- Implementing a more complex accounting system can easily become a burdensome process i.e. information systems, especially when computerised, can be very complex, time consuming and costly to alter. Moreover, because any such modification will have an impact on working procedures, there will most often be a lack of incentive to change among the employees and workers.

Most of the issues raised here have actually been identified in the more traditional management accounting literature, for instance when reviewing barriers to the implementation of ABC. One of the main issues with ABC is the difficulty of implementation. Identifying activities or processes to be allocated properly is complex and takes a lot of effort. It requires processes to be adequately mapped throughout the organisation. For a company that has undertaken a quality improvement programme, or inititated an effort to reengineer business processes, a major part of the work may already be completed, but for those who have not it is likely to be a major challenge.

Hence, just as anything else, ABC, EMA and affiliated cost accounting methods such as FCA are no panacea. They are potential operational strategies that need to be carefully reviewed for applicability. The empirical study conducted with various industrial companies and reported on in the next section, was aimed at initiating such a review.

3.2 Presentation of the results of the empirical study

In order to assess both current practices and potential interest in waste accounting, fourty-one companies and production sites were approached to request an interview. With twenty interviews conducted, the success rate was just below 50%. Five interviews were conducted in May during the initial screening phase of the project in order to help scoping the research. Fifteen were conducted in June and early July using a questionnaire in order to try to standardise questions and answers. Although shorter and less comprehensive, the five initial interviews did allow to assess roughly the level of waste accounting at the companies/sites.

Most interviews were conducted with staff-members working at specific production sites.rather than corporate headquarters. This is because the very practical and immediate benefits of waste accounting are most likely to be identified at the site rather than corporate level. It also easier to demonstrate the benefits at a specific manufacturing site first and then extend the new working procedures to the whole company, using the successful first implementation to convince potentially reluctant workers and/or management staff.

The following sub-sections provide a summary and partial analysis of the answers received i.e. there are many different potential influence factors and only those most relevant to the scope of the research were reviewed.

3.2.1 The companies interviewed and the questions asked

The selection of companies was operated as described in Section 1.7.1 (page 9), and focusing mostly on existing customers of Natlikan Sustainability. The table below provides a list of companies (mostly specific production sites) interviewed between mid-May and mid-July 2006, in chronological order. More details can be found in Appendix I on page 90.

Table 8: List of companies interviewed

	Company	Industry	Main products	Position of the interviewee(s)
Interviews conducted in May during the initial screening phase				
1	Lantmännen Mills	Food	Cereal-based products	Environment and Quality Manager
2	Findus	Food	Frozen-fish products	Quality Manager
3	Volvo Trucks	Automotive	Trucks	Corporate Environment and Quality Manager
4	Lyckeby	Food	Potato/starch products	Corporate Environment and Quality Manager
5	Gambro	Medical	Renal and blood components technology	Corporate Production Director
Interviews conducted in June and July with the more comprehensive questionnaire				
6	Skanska	Construction	Building and infrastructure	Corporate Environmental Coordinator
7	Expancel	Chemicals	Microspheres	Environmental Coordinator
8	Hydro Polymers	Chemicals	Chlorine, VCM and PVC	Environmental Engineer
9	Volvo Trucks	Automotive	Cabins for trucks	Environmental Manager, Accountant
10	Ericsson Power Modules	Electronics	Current Regulators and Converters	Environment, Health and Safety Manager
11	Norrmejerier	Dairy	Dairy products	Environmental Manager, Controller
12	Seco Tools	Industrial Machinery	Hard Metal Powders	Environmental Coordinator
13	Holmen Paper	Pulp and Paper	Pulp, Paper, Newspaper	Environmental and Quality Engineer
14	Trelleborg Protective	Industrial Clothing	Protective Clothing	Environmental and Quality Manager
15	Kraft Foods	Food	Potato based products	Environmental and Lab Manager
16	Powerwave	Communication	Antenna systems	Quality Engineer
17	Marbodal	Kitchen	Kitchens and furniture	IT and Environmental Manager
18	Amcor Flexibles	Packaging	Film rolls	Eenvironment, Health and Safety, and Real Estate Manager
19	Finnveden	Automotive Components	Metal structures	Environmental Coordinator
20	Trelleborg AVS	Industrial Components	Vibration insulation components	Environmental and Quality Manager

The questionnaire used for the last fifteen interviews was divided in the following sections:

- Section 1: Information about the interviewee;
- Section 2: General information about the production site;
- Section 3: Information about the waste streams generated during the production process and the management of this waste;
- Section 4: Information about the current accounting and costing for waste;
- Section 5: Interest in expanding the current definition of waste costs;
- Section 6: Development of an internal performance indicator for waste costs;
- Section 7: Summarising results.

The list of thirty-five questions covered with the interviewees can be found in Appendix II on page 91.

The last section of the questionnaire consists of a draft classification of some of the costs that can be related to the generation and management of solid waste; this classification was based on the one presented at the end of Chapter 2. It was used as a reference point during the discussions and was aimed at enabling to assess both the current degree of complexity used to account for waste costs, as well as the extent to which, according to the interviewee, it would be interesting to include additional cost categories, to increase waste accounting complexity towards RWA, FPCA and FCA. In practice however the terminology had to be sometimes simplified and partly altered in order to: (1) Make it more understandable and relevant for the interviewees, (2) Not to pollute the discussion with academical terminilogy, and (3) Be able to focus on assessing current and potential waste accounting practices from a practical rather than conceptual angle of approach.

The interviews were conducted using both open- and closed-end questions. In the case of open-end questions, examples of potential answers were sometimes suggested to guide the discussion, especially when discussing accounting and cost-related aspects, as quite many interviewees were not very familiar with accounting concepts and principles.

Moreover, not all questions were asked to all interviewees. It was quite easy to assess at an early stage of the interview, both the current level of waste accounting at the site, and the specific knowledge of the interviewee in the area. Thus, some of the questions were not always worth askings as the answer was self-evident e.g. Section 7 was not covered with a couple of interviewees having expressed no interest whatsoever for waste accounting during the conversation.

3.2.2 Presentation of the information collected during the interviews

The aim of this sub-section is to retribute the information gathered during the interviews as objectively as possible. To enhance clarity and readability, results are, when possible summarised using graphs or figures.

3.2.2.1 Current level of waste accounting

Results presented rely on the information collected in Sections 4 and 7 of the questionnaire. The five interviewes conducted in May are also included here.

As expected before starting the empirical investigation, the average degree of cost accounting in place for waste at the companies and production sites reviewed is low. In most cases, there is actually no cost accounting at all for solid waste: only the cash costs are being considered and reported. Thus, to present the results, the modelling of waste costs presented at the end of Chapter 2 can be simplified and scaled down to retain only the following five levels of waste accounting complexity: (1) Cash costs of waste, (2) Wasted raw materials, (3) Internal waste handling and treatment costs, (4) Other manufacturing costs (labour, energy, water, maintenance, etc.), and (5) Additional types of costs (contingent, less-tangible and external). Cost categories (1) to (4) correspond more or less to what has been referred to previously as RWA, while adding category (5) implies moving toward FPCA and FCA.

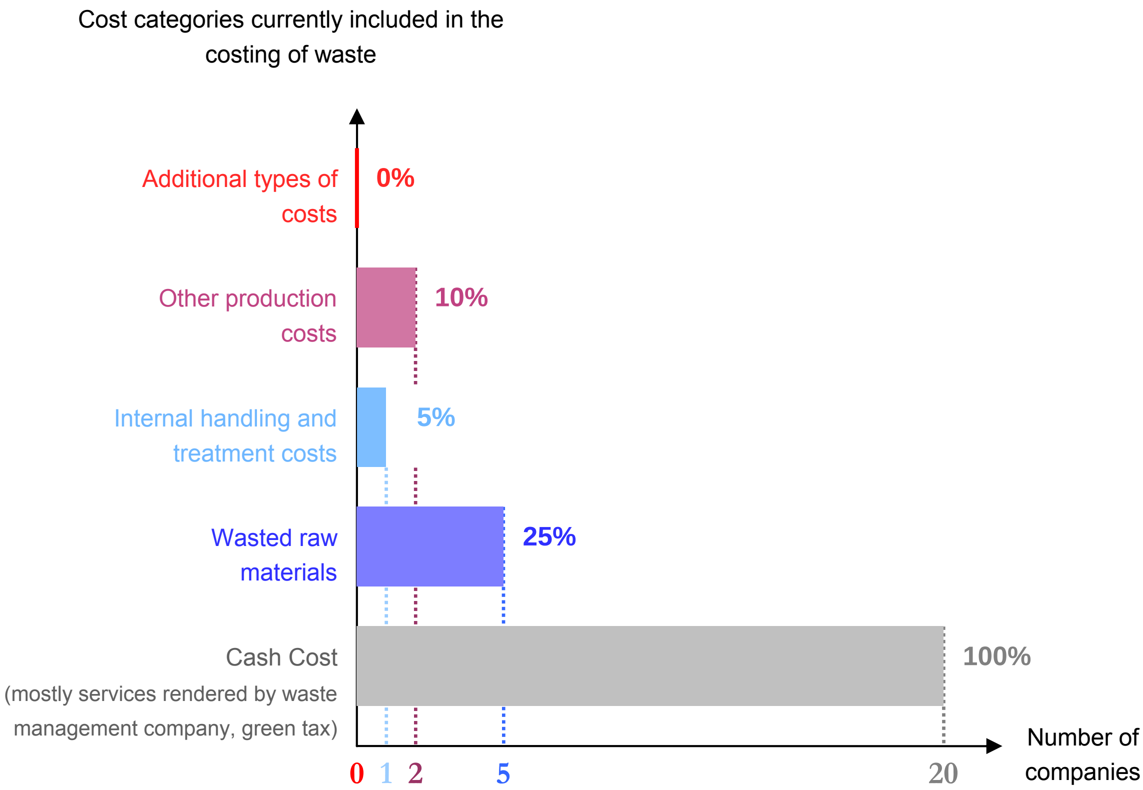

Figure 11: Levels of waste accounting at the companies reviewed

All 20 companies/sites interviewed take into account the cash cost of the waste they generate (mostly what they have to pay to their waste contractors, but also green taxes when applicable), which is actually not avoidable since such cash outflows result in financial transactions and are therefore part of the mandatory bookkeeping and financial accounting.

Because other types of waste-related costs do not result in a direct payment, they appear to be less obvious to most companies, which most of the time account for them as overheads:

- One company calculates a separate cost for internal handling and treatment of waste; this was only possible because the site has dedicated staff only dealing with waste i.e. it is easy to account for labour costs as they are 100% direct cost.

- Five companies/sites allocate the purchasing cost of wasted raw materials to waste; and

- Out of these 5, even fewer consider 'other production costs' (mainly labour, energy and maintenance) when calculating the cost of waste.

The company with the most 'advanced' accounting for process waste had what can be described as a 'dual definition of waste costs'. The following two categroies of costs are considered and reported:

- The cash-cost of waste: collection and treatment costs as well as landfill tax, and

- A 'calculated cost' of waste, consisting of allocating various production costs to waste, mostly raw materials, labour, energy and maintenance.

In cost accounting, so called 'calculated costs' are used for those costs that are not directly considered in bookkeeping (financial accounting) and have to be computed. Most costs to be looked at for performance management purposes actually have to be calculated as they are not available as such in the financial accounting system. However some SMEs do not have a separate cost system for controlling and management and rely on data generated by their financial accounting department to manage costs internally.

To try to summarise the empirical results described above, the following observations can be made about the current uses of cost accounting for solid waste:

- The cost of non-product outputs is most often not being monetarised separately;

- If starting to look at waste as a sign of production inefficiencies rather than just a cash cost, waste raw materials appear to be the first cost companies are considering;

- 'Other production costs', such as labour and energy are seldom accounted for;

- None of the companies had viewed the possibility of going beyond manufacturing costs to include contingent, less-tangible or external costs.

3.2.2.2 Interest and willingness in expanding the definition of waste costs

Results were gathered in Sections 5 and 7 of the questionnaire. The questions asked during the interviews conducted in May were not detailed enough to enable to report on those five companies in this section. Thus, only fifteen interviewes are reported on.

Many interviewees acknowledged some shortcomings in the existing waste cost accounting and reporting system at their site/company. Answers to whether it could, according to them, be of potential interest to include additional types of cost in the cost of waste are summarised by the diagram below. [11] Being influenced by the interviewees' views on the topic, the answers

[11] The classification of waste-related costs used for building the diagram is consistent with the one used during the interviews.

might reflect his/her personal interest and views, rather than their effective relevance for the site/company.

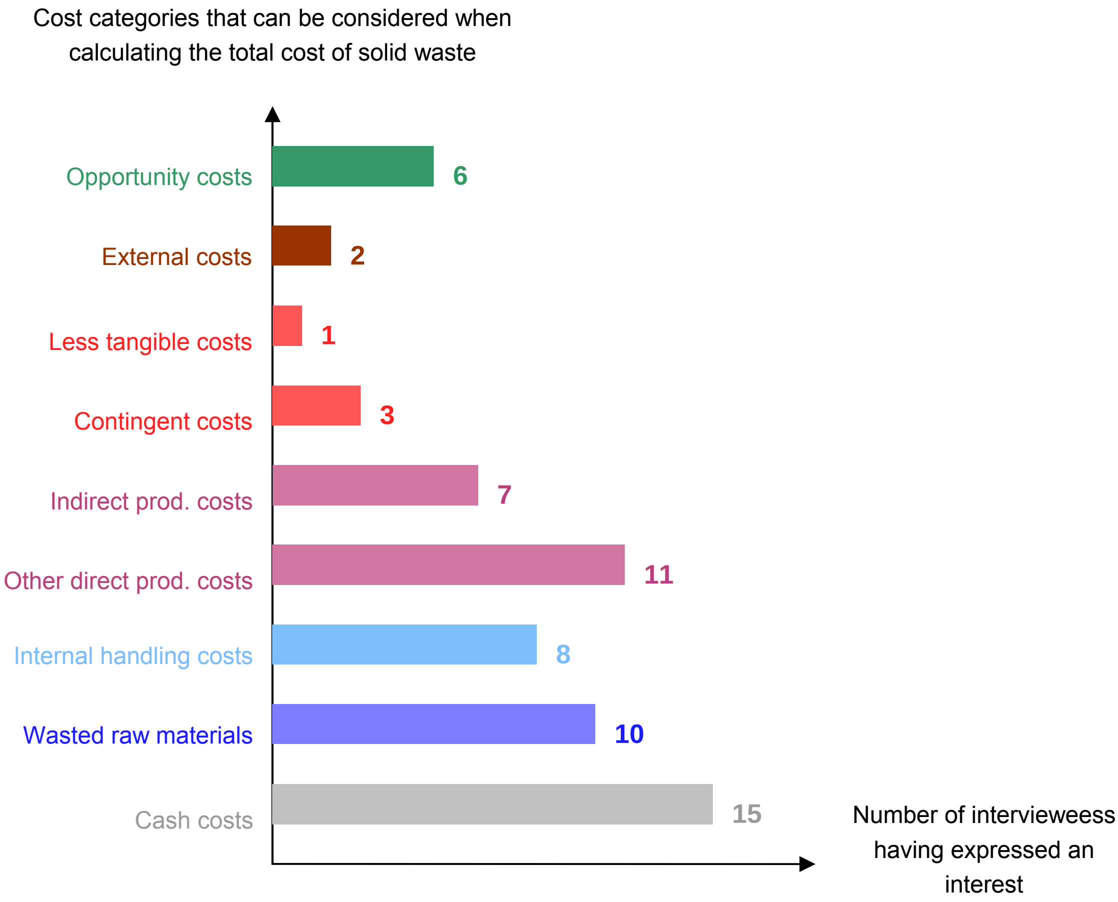

Figure 12: Potential relevancy of different categories of waste-related costs

The following comments can be made on the basis of the results obtained:

- Without surprise, the costs most interviewees thought would be of most interest are those relatively easily quantifiabl private/internal costs i.e. internal handling, wasted raw materials and other production costs both direct and indirect, depending on how easily those costs can be specifically allocated;

- Going beyond manufacturing costs (contingency, less-tangible and external) is of less interest to a company unless it is faced with liabilities issues due to the use of hazardous material and generation of hazardous waste;

- Opporunity costs (money that has been spent on waste instead of on a value-adding activity or loss sales), as defined in Section 2.1.2.2 on page 16, was viewed by some interviewees as a good educational apporach if wanting to convince both management and workers of the potential benefits to be achieved in trying to reduce waste and associated costs;

- The two interviewees having mentioned external costs actually referred to internalised externalities such as the cost of the tradeable permits introduced when implementing the Kyoto Protocole. Those should actually be considered as part of the 'cash cost' of waste since they result in a cash outflow;

It is important to note that these results do not provide any information about how easy or difficult it would be to implement the suggested change in practice. The question were formulated in order for the interviewee to provide an indication of whether each specific cost category could be of relevance to consider for his company/site, not taking into account the potential complexity of trying to do so in practice.

Now, towards the very end of the interview, the more practical willingness to expand the definition of waste costs was then assessed when asking each interviewee whether their site/company would be interested in doing some actual work in the area of waste accounting. Although sometimes ambiguous and obviously subjective, the reponses of the 15 interviewees,, as well as those received furing the five initial interviews can be summarised using the traffic light analogy, as per the figure below:

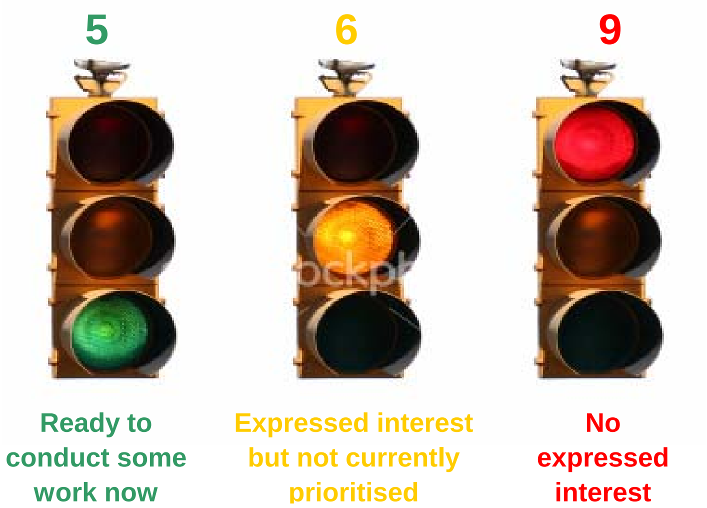

Figure 13: Number of interviewees with practical interest in waste accouting
Source: Istockphoto, 2006 [12]

Only a quarter of the interviewees thought there would be an immediate interest at their site to start doing some work to account for waste costs in a more comprehensive way. This can be due to various driving forces such as:

- An identified specific issue for the company/site that has not been dealt with yet e.g. highly inefficient use if raw materials, difficulties in justifying substitution from a more to less hazardous material or substance;

- A more general understanding that cost accounting for waste is something of interest for the company/site given the types and quantities of waste it generates and the management solutions used to date i.e. waste accounting is expected to enable to highlight potential economical and environmental benefits to be achieved;

[12] Picture Available from Istockphoto at http://www.istockphoto.com

- A personal interest of the interviewee i.e. independtly from whether waste accounting is assessed as being relevant for the company/site, the interviewee was interested in trialling waste accounting to find out what range of figures it would produce.

The 75% of sites/companies with no desire or interest in engaging in some work in the area of cost accounting for waste motivated their answer with the following main explanations:

- The expected benefits would to be too low compared with the resources that would need to be invested; and/or

- Waste is already well under control e.g. "*We already have an idea of how much our waste costs and we are trying to reduce the costs*" or "*A lot of work has actually been done to try to minimize waste of raw materials, water and energy.*"; and/or

- Advanced waste cost accounting is just not something relevant for their company in general. Even if it could be of interest to find out about the real amount of waste-related costs, those would not be high enough to have an impact on the company's bottom line.

One of the emails received from a company initially contacted but with which no interview ended up being conducted, summarises the points above: "*We mainly account for the cash costs for waste. We do study waste of raw materials, but not in connection to waste costs. A lot of work has actually been done to try to minimize waste of raw materials, water and energy.*"

Providing more detailed information about which specific company was interested or not would be likely to be of interest for the reader. However, given the fact that only one interviewee per company/site was conducted, it is not possible to ensure the opinion expressed by each interviewee is representative of the views of the company/site as a whole.

3.2.2.3 Waste costs reporting practices

One of the questions asked during the fifteen interviews was whether the interviewere personally considered waste related costs as environmental or more generic production costs. At this stage, the question was only about the general perception of how waste-related costs are considered among companies, not going as far as asking the interviwees whether and how these costs should be allocated to the production department instead of being kept as environmental costs.

The answers given were as follows:

- Seven replied they consider waste costs as production costs;

- Six that they consider them both as environmental and production costs; and

- Only two that they consider them strictly as environmental costs.

This outlines the potential for waste data (both quantities and costs) to be included in various information systems and reporting streams i.e. traditional management reporting, environmental reporting, production statistics and costing, as well as quality management.

However, when looking at the existing reporting situation at the companies reviewed, waste data is almost always exclusively part of the environmental management and reporting system. This outlines the following paradox: interviewees mostly agreed with the statement that waste is somehow related to production efficiency and is therefore more than just an environmental aspect to be kept under control, but they also acknowledged that waste quantities and costs are very seldom linked with performance management activirties.

3.2.3 Multicriteria analysis of the information gathered

The purpose of this section is to analyse the results presented in Section 3.2.2 and to provide some of the potential explanation factors for those by reviewing different factors that can participate in explaining the existing degree of waste accounting at the sites reviewed. Because the empirical study consisted of a review of companies operating in many different industries, the analysis focuses on broad influence factors. The identification of more company-specific factors would have required an initial narrowing down of the research to an industry or a type of companies in particular.

3.2.3.1 Factors with no or low impact on the level of waste accounting

The first two sections of the questionnaire were aimed at gaining a general understanding of the situation concerning environmental management at the sites reviewed. Some factors appear to have a low, or even no impact on the way in which sites and companies define their waste costs.

Certified EMS

Thirteen out of the fifteen sites and companies interviewed have a certified EMS in place, including both sites with low and relatively high degrees of waste accounting complexity. Thus, a certified EMS in itself does not seem to promote an improved cost accounting for waste. A few interviewees made the comment that it could actually work the other way around: an improved cost accounting for waste could help justifying the annual expense of having and keeping a certified EMS, by enabling to identify cost reduction opportunities and making the link between environmental management and operational performance.

Now, it would also have been interesting to analyse the impact of a certified quality management system, but this information was unfortuntaley not collected from the interviewee as it had initially not been identified as necessary. However, the link between environmental and quality management will be partly analysed in Section 3.2.3.3, when drawing a parallel between cost accounting for poor quality and cost accounting for process waste at the sites/companies reviewed.

Environmental Permits

All companies obviously have to comply with the general legistlation on waste, but many also need an environmental permit to operate, either according to thee EU Integrated Pollution Prevention and Control (IPPC) directive, or according to the Swedish Environmental Protection Act (Miljöbalken). Such permits are given out either by national, regional or municipal authorities depending on the level of environmental impact, and set specific conditions to be fulfilled. Companies classified in so called categories A and B have to hold permits placing limits, according to the legislation in force, on the quantities of water used and discharged as well as air pollution. A- and B- plants also have to provide information about waste in the annual environmental reports sent to competent authorities. Class-C companies only need to provide notification of their environmental impacts.

With regards to solid waste, permits do not place an upper limit on the quantity of waste a site is entitled to generate; they only require waste management and treatment solutions to be prioritised according to the waste hierarchy (refer to Figure 5 on page 28). Hence, one can say such permits do not have a direct impact on the quantity of waste a site generates. As per the table below, it is therefore not suprising that the level of waste accounting at the sites and companies reviewed cannot be correlated with the need to hold an environmental permit.

Table 9: Environmental permits and levels of waste accounting

	Cash-cost	Wasted raw materials	Production costs	TOTAL
No permit needed	3	-	-	3
B-companies	4	2	-	6
A-companies	4	-	2	6
TOTAL	11	2	2	15

One thing that an A or B permit does though, is to place a production cap on the site. This could indirectly limit the quantity of solid waste that will be generated by the site but is not likely to be systematically the case for the following reasons:

- Allowances are usually higher than the current production levels to provide a buffer allowing for some economic growth. Moreover, additional production allowances can be obtained under certain conditions;

- Such a permit will not differentiate a 'waste-efficient' from 'waste-inefficient' site. If both produce the same amounts of the same product, but one generates double the waste than the other, the permiting system will not place a restriction on the quantity of waste produced by the inefficient site. Hence, it will not encourage the later to view waste as a sign of inefficient production, and will therefore not promote the use of cost and management accounting methods for waste, RWA for instance (Section 2.3.1 page 29).

Size of the manufacturing site

A third aspect that does not appear to have an impact on the way in which waste costs are considered (or not) is the **size of the production site**. The number of employees working at the different sites, which ranged from about 90 to more than 1500, was retained as a proxy for the size.

No correlation, whether positive or negative, was found with the level of waste accounting. Sites with no cost accounting employ a wide range of number of employees, while the few sites having extended their waste accounting to include the cost of wasted raw materials and some additional production costs are mostly within the average size of sites reviewed.

3.2.3.2 The impact of the existing definition of waste costs

When asked about the biggest production costs for their site (question 6), interviewees mainly mentioned labour, raw materials and energy. When questioned about the relative importance of waste costs in the total production costs, most of them outlined that they come at the bottom of the list, which would tend imply that there is no reason to consider waste as a focus for cost minimisation and optimisation activities.

Now, according to the literature reviewed on environmental and waste accounting, the real costs associated with the production of solid waste are being highly underestimated by the industry. Including the cost of wasted raw materials as well as additional production costs is expected to result in waste costs being multiplied by four to twenty times compared to the waste disposal costs (cash-cost). Assessing the potential for such a dramatic increase at each of the site reviewed was not possible due to time and data-accessibility constraints. However, some elements of answer can be provided using the qualitative answers given by the interviewees.

Looking at the responses gathered, it can be concluded that the existing cost accounting in place for solid waste has a strong impact on the way waste is considered i.e. either as a cost to be managed and minimised, or just an environmental aspect to be kept under control. The current situation, where most sites and companies do not include waste in their cost management and reporting activities, can be explained by the following causal relation:

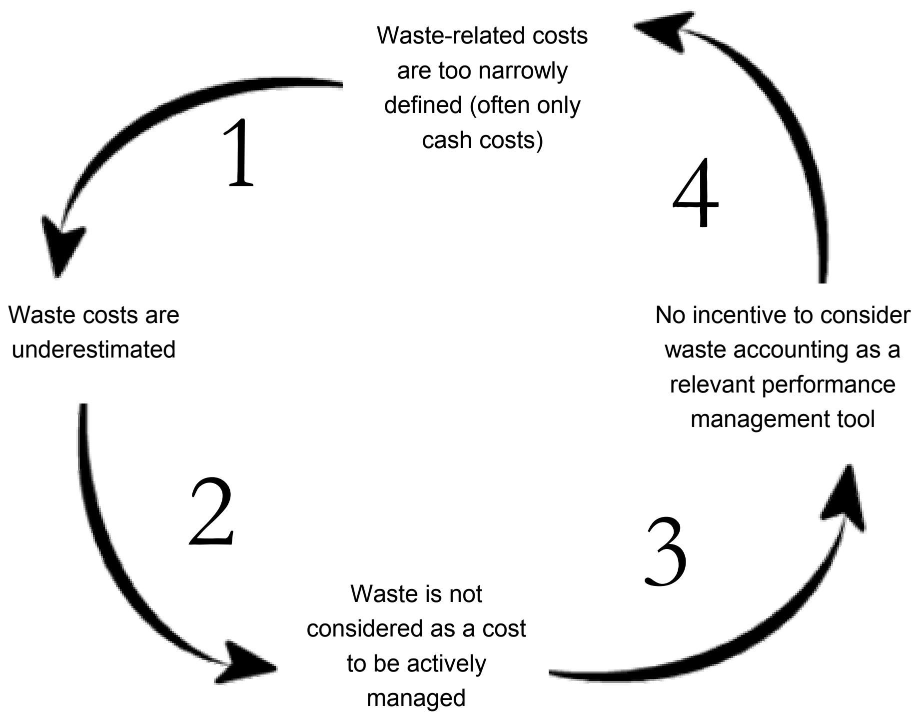

Figure 14: Underestimating waste-related costs: a vicious circle

The following statement summarises the figure: the narrower the current definition of waste-related costs, the lower the attention paid to solid waste as a cost to be managed. Consequently, very few of the fifteen out of twenty sites that only account for cash-costs consider waste as cost to be actively managed, especially not in relation to process efficiency. For those sites, waste is mainly an environmental aspect to be kept under control, with a bill to be paid to contractors for collection and treatment, and eventully green taxes to authorities e.g. landfill tax. As a result, the perverse incentive to disregard waste costs is even stronger if collection, treatment and disposal costs (cash costs) are low. This is because waste reduction will be seen as an economically viable option only if it results in clearly identifiable and measurable cost avoidance, which for most decision-makers consists of avoiding waste disposal costs since it is usually the only waste-related cost accounted for.

Now, fairly simple changes to the accounting procedures, such as including wasted raw materials in the cost of process wastee, have the potential to influence decisions on more environmentally sound waste management practices being or not being implemented, by providing decision-makers with improved information on the real cost of the waste generated.

3.2.3.3 Process waste vs. defects cost accounting

In the first two chapters, a link between waste and quality management was identified. In order to try to understand this link between the two systems, the matrix below provides a comparative analysis of the levels of cost accounting at the companies/sites interviewed, respectively for process waste and defects (cost of poor-quality). Given the observation made that none of the companies/sites reviewed have expanded their cost accounting beyond manufacturing costs, only the following three potential levels of cost accounting were considered to build the matrix:

- No cost-accounting at all i.e. only the physical quantities are accounted for and reported (units or tonnes of defects and wastes);

- Allocation of the cost of wasted raw materials to the defects or wastes generated; and

- Allocation of both wasted raw materials and other production costs (mainly labour, energy and maintenance) to the defects and wastes.

Table 10: Quality vs. waste accounting at the companies reviewed

		Cost accounting for waste			
		Quantities only	Wasted Raw Materials	Production costs	TOTAL
Cost accounting for defects	Quantities only	1	0	0	1
	Wasted Raw Materials	1	0	0	1
	Production costs	8	3	2	13
	TOTAL	10	3	2	15

For five of the twenty sites and companies contacted, the information collected did not allow to place them in the matrix, which explains why the total is only of fifteen.

The results presented can be interpreted in the following way:

- Cells shaded in blue: If the the cost accounting for non-quality is not developed, the cost accounting for waste will not either. In other words, waste accounting is never more complex than quality accounting;

- Cells shaded in pink: Those companies with a comprehensive cost accounting for process waste all have a pre-existing comprehensive quality costing system as well. Thus, a comprehensive cost accounting for defects seems to be a good potential starting point for improving cost accounting for process waste.

- Cell shaded in purple: Many companies account for production costs for defects but have no-cost accounting for waste. Hence, a comprehensive cost accounting for defects does not systematically imply that the same is being done for process waste.

Cost accounting for defective semi-finished ot finished products is very often well developed in the industry mainly because quality has been a major area of concern and focus over the past tweny years. While defects are considered as a major sign of manufacturing inefficiency, it is seldom the case for process waste, which explains why waste accounting is far less developed than quality accounting, despite process waste usually representing a much larger portion than defects in the total quantity of waste generated.

RWA, as defined on page 30, includes the material purchase values and additional production costs in the total cost of waste. By doing so it aims at mimicking the progress made in the area of quality management in order to:

- Account for the value-added included in the waste generated;

- Link waste management with production and process efficiency.

A few interviewees expressed their will to see waste gaining as much attention as quality issues, and, when asked, acknowledged that improving cost accounting for waste, would be likely to participate in achieving this objective.

3.2.3.4 Data and resource availability and 'soft factors'

Towards the end of the discussion, the interviewee were asked to mention what, according to them, would be main drivers, benefits and barriers if trying to implement a more comprehensive cost accounting system for solid waste at their site/company.

Because the question was open-ended, the answers given varied a lot. Despite the strong likelihood that those answers were highly influenced by the personal views of the interviewee, they provide a good overview of opinions within the industry.

To try to somehow homogenise them, responses have been classified in four categories in the table below: (1) Justifying waste accounting, (2) Bringing focus on waste costs, (3) Making resources available for it, and (4) Having the required data available. The table below consists of a summary of answers received:

Table 11: Drivers, benefits and barriers mentioned by interviewees

Area	Drivers and potential benefits	Barriers and drawbacks
(1) Justification	High proportion of waste in relation to product output Waste represents a fairly important cost Try to gain a better understanding of the true cost of waste Save money Identify and justify potential process improvements Decrease environmental impact	Waste is not a big cost Benefits need to be demonstrated Low expected benefits compared to the investment required Needs acceptance by higher management Needs acceptance by shop floor e.g. procution line staff, project managers
(2) Focus	Justify bringing waste costs in focus Motivate workers by making specific processes accountable for waste quantities and costs	Lack of interest within the organisation Lack of focus on waste Focus on compliance and legislative requirements
(3) Resources	Use of external resources to demonstrate the interest and benefits to be achieved Extend existing quality accounting system to include process waste	Lack of financial and human resources to be allocated Needs to be big to justify time and money to be invested
(4) Data	Data availability thanks to existing tracking systems in place such as ABC for production costs, mass-balances, etc.	Lack of data Complexity of extracting and isolating waste-related cost data

The answers do not provide new information compared to what has been outlined in the literature, but confirms that the main barriers are:

- Being able to prove the interest of waste accounting given the scarce human and financial resources companies are ready to commit to it i.e. gaining support from upper management and acceptance by shop floor that it is worth focusing on understanding the total cost of waste better;

- Making the required data available given the limitations of the existing information and accounting systems, and operating the changes in a simple and user-friendly way.

3.2.3.5 Waste quantities, streams and management solution

The previous section enabled to outline the need to be able to justify waste accounting by poving its relevance and in particular the gains to be achieved from it. An issue one can be faced with when trying to do so is the perception within the orgnisation that there is no need for complexifying cost accounting for waste simply because the characteristics of waste and waste management do not require it. Many factors can strengthen or weaken this perception, including the following ones:

(1) The quantity of solid waste generated

It was not possible to collect waste data from all interviewees, and it would actually not have been possible to process and analyse such data for twenty companies. However, the general discussions conducted with the interviewees allowed to confirm the positive correlation between the quantity of solid waste generated at a given site and the potential relevance of waste accounting: the higher the quantity of waste generated, the higher the interest expressed by the interviewees for trying to improve cost accounting for waste. This positive correlation was even stronger in the cases of sites handling hazardous materials and generating hazardous waste i.e. a relatively low quantity of hazardous waste generated could be enough to justify the need for waste accounting.

(2) The causes and origins of waste

As underlined in Section 2.2.3, there are many potential causes of waste. The existence of waste within a manufacturing process may indicate inefficiencies within the production process, technical problems in particular machinery, management systems inefficiencies, human error or lack of knowledge/training relating to operational and maintenance procedures, raw materials and product quality issues, etc.

Quite a few interviewees mentioned that their organisation considers its solid waste as being mainly ‘unavoidable’, due for instance to the nature of the process or the technology used. This was used as a justification to show little interest in the possibility for a more comprehensive cost accounting for waste because the interviewees assumed that no gains would be derived from it. In other words, reducing waste further is not considered as achievable under the current conditions, even if an improved cost modelling allows to show that the real cost of waste for the site is many times more than what currently calculated.

However, this view can be discussed. It is most often based on the consideration of waste as an environmental issue not related to material and process efficiency, when one of the main gains to be achieved by using waste accounting to isolate waste as a variable production cost, is to outline the negative correlation between waste costs and production optimisation.

(3) Quantities, cost and efficiency of raw materials usage

Looking at the answers gathered during the interviews, it appears that one of the most relevant and less complicated changes that could be implemented when getting started with cost accounting for waste, is to include the cost of wasted raw materials. The subsequent increase of waste costs compared to the previous situation where only cash-costs were accounted for will be most impressive for those companies:

- With high material costs in proportion to the total production costs;
- Using valuable/expensive raw materials;

- Dependent on raw material markets prices;
- Characterised by a current low material-efficiency i.e. high proportion of material wasted compared to the product output produced.

(4) The cash-cost of waste

Among the companies reviewed, those taking wasted raw materials and production costs into consideration, most generate big quantities of waste to be incincerated or disposed of, with an associated relatively high cash cost. On the contrary, for those companies whose waste consists mostly of valuable recyclables or reusable waste, the interviewees outlined that there is little or even no incentive within the organisation to consider waste costs as an issue requiring attention. Thus, it can be concluded that the higher the cash cost of waste collection and disposal, the higher the likelihood that the site/company will have an interest in looking at waste-related costs in a more comprehensive way in the future. If a lot of the waste generates an income or is taken care of by the waste contractor at no cost for the site, convincing decision-makers of the interest of waste cost accounting will be more of a challenge.

If the person responsible (often the production or site manager who's budget is impacted by the cash costs of waste) does not see the cost of waste disposal as high, he won't be prioritising waste minimisation, unless the cost accounting system is improved to start accounting for additional cost types. It has been previously underlined that there is a perverse incentive not to do so.

It should be pointed out that the financial incentives given by municipal and private waste management and recycling companies define most of the cash cost of waste for a given production site.[13] Those companies therefore have a very strong impact on whether the site consideres waste costs as an issue or not. Depending on the waste treatment technology they prioiritise (recycling, incineration, biogas recovery, etc.), vested interests will influence the service cost they will charge (or not) the waste generating industries.

(5) The ambiguity of reusable waste and by-products

As per the definition of waste provided in Section 2.2.2, waste reused on site and by-products used by another industry are in principle not considered as solid waste because they are not intended to be discarded of. The companies and sites reviewed have consistent approaches with this definition. Those that generate reusable wastes or by-products considered both as valuable outputs of the production process rather than potential signs of inefficiencies with an associated cost. In other words, the higher the share of reused waste and by products in the total amount of non-product output, the lower the incentive to consider cost accounting for waste as a relevant management tool.

However, the following ambiguity can be outlined: once a site has started reusing some if the waste it generated, the incentive to continuously work on reducing this specific waste stream will be much lower. Thus, on the one hand, waste reuse is an environmentally sound practice but on the other hand, it can sometimes prevent a production site from considering the full production cost of its waste, which in return can hinder the achievement of waste prevention via improved material and process effeiciency. Ideally, a cost-benefit analysis including both environmental and economical parameters should be run between (1) reusing the waste

[13] The remaining part of the cash cost of waste being defined by authorities via the use of green taxes, such as the landfill tax.

generated, and (2) actually trying to minimise or even prevent the generation of this waste in the first place. Waste accounting can enable to produce the data needed to run this comparative assessment.

(6) The perception within the organisation of how well it currently performs in managing and minimising the waste it generates

This will be a strong driver or hindrance to the implementation of waste accounting. Most of the interviewees underlined from the start of the discussion the amount of work already done in the area of waste at their site/company as well as the focus on continuous improvement. Such statements can be interpreted as both objective beliefs that good work is being done, as well as defensive reactions when being faced with potential gaps in the existing waste management, minimisation and prevention activities and strategies.

Conclusions:

- When the cost of waste is currently measured as low, prevention and minimisation do not appear as economically viable options. Although cases when environmental/waste accounting isa net-cost to the industry cannot be excluded, many industries base such preconceived judgement on an underestimation of the true cost of the waste they generate;

- Hence, most of the arguments given by the interviewees to justify not looking at the production costs of waste (RWA) are actually not valid as such. Even when the cash cost of waste is low (e.g. waste consisting mostly of recyclable or by-products, no cost for burnables, no landfilling), the site can still be wasting resources such as raw materials, labour or energy, on generating waste;

- By promoting material efficiency, waste accounting can allow to either produce more product output with the current level of resources and/or reduce the quantities of materials needed for the current level of production;

- It must howeveer be acknowledged that cost accounting for solid waste can be more or less economically relevant for companies depending on many different factors e.g. quantities and types of process waste generated, structure of production costs e.g. share of material purchasing costs in the total, etc.

In addition, it is important to point out that the influence factors listed and analysed in the section above do not provide a complete list; there selection was based on both the literature reviewed and the outcome of the interviews conducted, which cannot gurantee full-representativeness. Thus, many other factors, both internal and external to the company, could be considered as playing a role when assessing the practical relevancy of waste accounting. Some of them, such as the level of cost-competition intensity in the industry, or the role played by customers in driving maximum material efficiency, will be considered in Chapter 4, which is dedicated to a case study of Finnveden, a producer of metal parts for the automotive industry.

3.3 Drafting an approach to initiate waste accounting

The best way to get started with waste accounting is to rationalise a facility and its processes, identify opportunities, and then conceptualise a solution. As there is no one-size fits all methodology, this section is only aimed at providing indications on aspects to be considered and possible angles of approach when doing so, based on the theoretical and empirical findings presented above. It also gives the reader an indication of the level of knowledge reached by the author at this stage of the research and the progress made in getting a fair understanding of how to approach cost accounting for industrial waste.

3.3.1 Understand the industry

Preliminary preparation work should be conducted in order to gain basic understanding of the industry the company is operating in, and in particular to identify:

- Driving forces e.g. level of competition, legislative pressure;

- Typical cost structure e.g. sensitiveness to raw material prices;

- Usual waste situation i.e. streams and quantities, separation, management, treatment, and disposal solutions;

- Best practices in the industry e.g. how well are front-runners performing and why?

This is to allow making an initial selection of key potential factors of influence as well as eliminate some factors that will clearly have no impact given the characteristics of the industry.

3.3.2 Gather information and identify waste-related costs

The next step is to gather information and data from the specific company/production site by:

- Conducting interviews with various staff members, and in particular in the environmental management, quality management, production management, and accounting departments;

- Gathering available documentation e.g. production flow chart, input/output models or mass balances, environmental reports (internal and external), production statistics, etc.;

- Collecting required and available cost data for future financial modelling of waste costs, including units of product produced, materials purchase and inventory, quantities and types of waste from different operations, energy and water usage, areas used for materials and waste storage, and floorspace rental costs, etc.

This is to enable both to map the company's/site's production process as well as understand its cost structure.

Something that could be of help is to prepare a list of potential waste-related costs, and run through them with the company to identify both:

- Cash costs: mainly waste management and disposal costs as well as green taxes;

- Potentially hidden costs: wasted raw materials, internal handling and treatment, direct production costs (labour, energy, etc.), indirect production costs (maintenance, capital depreciation, administration, etc.), potential liabilities, etc.

3.3.3 Analyse information and identify specific needs

At this stage, the information collected should be confronted with waste accounting theoretical concepts and potential degrees of complexity that can be implemented i.e. cash-costs, purchasing price of wasted raw materials, RWA, FPCA, etc. The different influence factors that will have an impact on the degree of relevancy of waste accounting for the specific site or company looked at have to be considered; they should include in particular:

- Characteristics about the waste generated such as quantities of waste including key efficiency ratios, types of waste including subsequent waste management solutions, stringiness of existing and future legislation, risk associated costs and environmental liabilities, etc.;

- Characteristics of the cost structure and current cost accounting system i.e. structure of environmental costs (amounts of overheads and cost allocation procedures), complexity of the existing cost modelling for waste, outcome of eventual past attempts to expand the definition of waste costs, etc.;

- The link between quality and waste management and accounting i.e. assess the relative shares of defects and process waste in the total solid waste generated by the site, review the current accounting for poor quality and assess whether it could be extended to process waste, etc.

At first there may not seem to be any areas of improvement but by questioning and probing into the various production processes and categories of waste-related costs, and examining inputs and outputs, opportunities for improvement are likely to arise.

3.3.4 Develop a performance metric

To initiate cost accounting for waste in a way that will be accepted by management and staff members, the improved modelling of waste costs should focus on costs most relevant to the company/site. According to the findings presented in Chapter 3, those are the costs included in the definition of RWA i.e. mainly raw materials, labour, overheads, and capital cost.

A complementary possibility would be to isolate costs related to waste management activities, which mainly include internal waste handling, waste treatment, and waste disposal. However, doing so has the disadvantage of keeping waste exclusively within the environmental department and therefore remaining in a situation where waste costs are decoupled from production costing and optimisation.

On the contrary, waste cost information is only likely to become an area of focus if merged with existing performance management activities and indicators. As underlined by Franz Figge, Professor of Corporate Social Responsibility at the University of Saint Andrews in Scotland, during a phone conversation, newly defined waste costs need to be made relevant the site/company by translating them in financial data i.e. quantify the impact of potential cost savings on operating profit margin and shareholder value (Figge, 3 July 2006). Thus, the financial modelling of waste related costs should allow to:

- Isolate waste as a variable cost in order to relate it to process efficiency;
- Undertake a sensitivity analysis of different categories ot waste-related costs;
- Use a cash/hidden cost ratio as an educational tool i.e. for each SEK spent on waste collection and disposal, how many SEK are actually wasted in production costs?
- Show how waste impacts on the production site's or company's bottom line e.g. impact on operational margin.

The characteristics of the new waste accounting system should also be agreed on e.g. develop a stand-alone financial waste accounting system versus integrate these measures into the formal accounting system or quality management system.

3.3.5 Recommend management applications

Finally, once a perfomance management metric has been developed, specific uses of the newly generated data can be identified in:

- Daily operations such as the improvement of operational procedures, the fine tunning of existing machinery, or the initiation of better waste sorting procedures, etc
- Strategic and investment decisions such as the purchase of new machinery, alternative choices in terms of technology and materialused, etc

The implementation steps presented above along with recommendations made for each of them, are based on the level of knowledge reached at this stage of the research work. The partial case study conducted thereafter allowed complementing these initial findings with a more thorough and company-specific review and analysis.

4 Partial case study

During the empirical study, a few interviewees expressed an interest in conducting some work to develop a more comprehensive cost accounting for waste. Finnveden was selected among those mainly because it had a cleary identified goal to be achieved in trying to engage in waste accounting i.e. raise management and workers awareness to the issue of raw material (in)efficiency. The chapter is however entitled 'partial case study' because the Thesis time constraints and the limited availability of Finnveden staff during the summer did not allow running a full analysis. It was for instance not possible to review the cost accounting system in place in detail.

Information was collected from Finnveden on three occasions:

- The initial telephone interview with the Environmental Coordinator using the questionnaire (July 4);
- A visit to the production site in order to meet personally with the interviewee, collect some of the data and documentation on waste, as well as be able to look at the facility and operations (July 12); and
- Telephone interviews with two additional staff members in order to gather complementary information and data: the site controller and the quality engineer (August 30 - September 7).

Chapter 4 is divided in two sections. The first one consists of a general presentation of the company and the specific production site reviewed, as well as a characterisation of the waste generated at this site. In the second one, the results of the assessment conducted are presented, that is both an evaluation of the existing accounting and reporting for waste costs, and recommendations on why and how to initate improved waste accounting.

4.1 Presentation of the case company

The information provided in this section was gathered from Finnveden's website, some of the documentation collected as well as the interviews conducted.

4.1.1 Finnveden Group

Finnveden Group is an international engineering group producing customer-specific components and systems based on metallic materials for the automotive industry. It employs about 2 900 employees and generates net sales of approximately 4 billion Swedish Kronor (SEK) per year. The headquarters are located in Gothenburg, and the group has production units in Sweden (8), Germany (1), England (1), Poland (2), and China (1). The Group's product offer is divided in three segments: 'body/cab', 'interior segment', and 'chassi'.

As per its website, the company's product offering is based on "*applications know-how, combined with metallic materials expertise and effective production and logistics processes*" (Finnveden, 2006). The following key success factors have been identified: operational excellence (quality and delivery performance), cost competitiveness (cost levels and capital utilisation), growth and globalisation (existing and new customers in new markets), and technology and innovation (skills and competence development). In order to optimise production efficiency, Finnveden uses a Group-wide solution known as 'Finnveden Production System', to allow continuous monitoring and appraising of output.

4.1.2 The metal structure business unit

Finnveden Group consists of three main product areas: Fasteners, Powertrains, and Metal structures. The case study focuses on the Metal Structure division, which develops, produces and sells interior and exterior metallic structures for applications in cars and trucks. The main customers are Volvo, Scania, DaimlerChrysler, Grupo Antolin and CarTopSystem.

The Metal Strcuctures headquarters and main development centre is located in Gothenburg, while manufacturing activities are divided between six plants located in Sweden (4) and Poland (2), each specialised in different metal forming processes and corresponding product assortment, as per the figure below. As part of Finnveden Group's global efforts to attain an optimal cost structure by increasing the share of labour-intensive production in low-cost countries, a manufacturing site in Sweden has recently been shut down, and production transferred, mainly to a new factory in Poland and partly to other factories in Sweden.

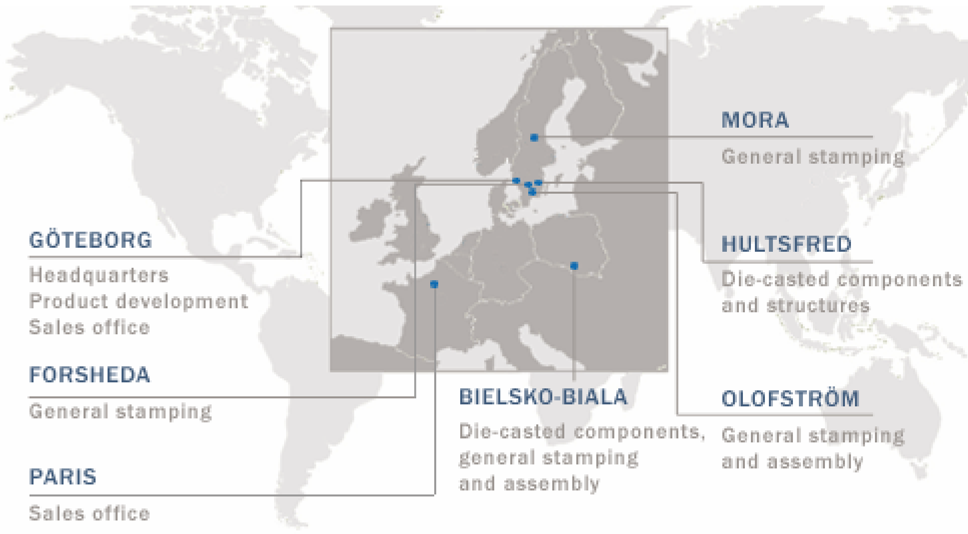

Figure 15: Finnveden Metal Structures locations
Source: Finnveden Group, 2006

The majority of the Metal Structures products fall into the 'body/cab' product segment, such as different sheet metal components, body reinforcements and crash protection structures. Products in the 'interior segment' consist of different sub modules for seats, instrument panels and retractable hard and soft tops. The 'chassi' segment includes engine sub frames, different steering and suspension components.

4.1.3 The production process at the Olofström plant

The main processes used at the various Metal Structures sites are cold chamber high pressure die casting and sheet metal forming (deep drawing, stamping or roll forming). The products are then finalised by different methods such as hard machining, drilling, joining, assembly and surface treatment. The Metal Structures product range involves sourcing different types of materials. Aluminium and magnesium are mainly used in casted products, while various kinds of high strength carbon- and stainless steel are used in pressed components. The kind of application that the product will be used for defines the choice of material, which in return, guides the choice of production method.

The production site under study is located in Olofström, which is by far the largest Metal Structures plant (Nilsson, 1 September 2006). The factory is located on the same site as a Volvo Cars facility, to which it was previously integrated before being acquired by Finnveden six years ago. In a very schematic way, the manufacturing process can be described as follows:

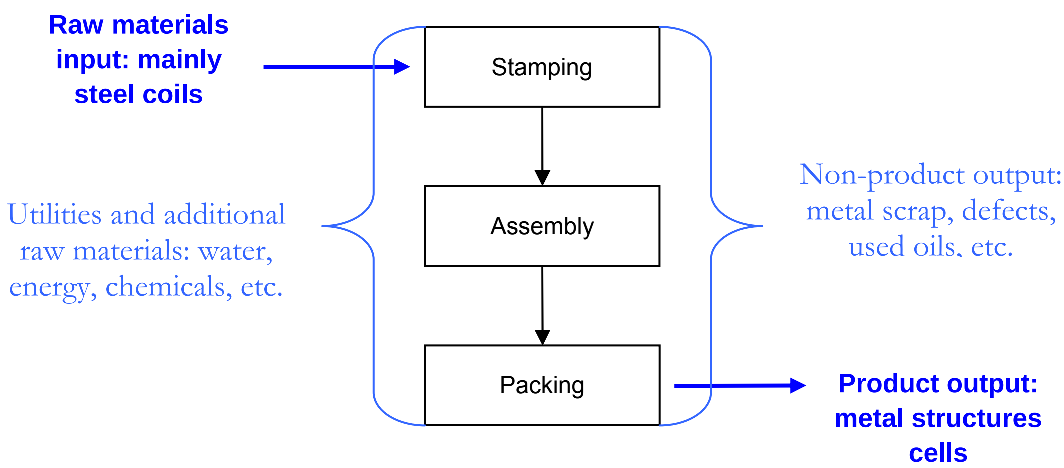

Figure 16: Simplified production process at Finnveden's Olofström plant

The site produces about five million products a month, generating an annual turnover of approximatively 550 billion SEK (Lexe, 12 July 2006).

However, as underlined by the Metal Structures Controller, there is currently much inefficiency in the process, preventing the equipment and machinery from delivering the maximum output. It was pointed out at that if a stamping machine capacity is 200 parts per hour, in practice only 140 in specification finished products are manufactured at Olofström. Because of this situation, the site is constantly behind schedule (big backlog), requiring very costly overtime to meet deadlines. The causes of such inefficiencies tend to be numerous and include the generation of defects, technical problems with the machines, as well as delayed raw materials reception from suppliers as it is often difficult to source steel at the time and in the quantities desired (Nilsson, 1 September 2006). This was confirmed during a telephone interview with Olofström's Quality Engineer (Svensson, 8 September 2006).

4.1.4 Characterisation of waste streams and management solutions

Waste generation at Olofström can be briefly summarised as follow:

- Most of the waste is generated during the stamping process and consists of wasted 'pure' raw materials, mainly from stainless steel coils. In 2005, the factory purchased about 26 000 tonnes of steel, from which only approximatively 16 000 tonnes were sold to customers as finished products. The remaining 10 000 tonnes, representing almost 40% of the total purchased, were 'wasted' and ended up as metal scrap that was sold for recycling (Lexe, 12 July 2006);

- In comparison to the stamping process, the assembly and packing stages generate little amounts of solid waste, mostly packaging waste (wood, cardboard, plastics, etc.);

- Fractions of hazardous waste are also generated at various stages of the production process, due in particular to the use of emulsioners and oils.

The table provides, for the January to June 2006 period, approximate quantities of the main waste streams at Olofström i.e. above half a ton generated:

Table 12: Main waste streams at Finnveden's Olofström site

Waste stream	Quantity in tonnes	Management solution
Steel	6 070	Recycling
Used oils and emulsioners	105	Treatment and incineration
Wood	101	Recycling and incineration
Unsorted burnables	36	Incineration
Aluminum	0,5	Recycling
Paper	8	Recycling

Source: Stena Gotthard AB, 2006

One single contractor, Stena Gotthard AB, collects all of Olofström's waste. Stena provides the site with a complete range of services (rent of sorting containers, collection, continous access to detailed statistics about quantities of waste collected and associated cash-cost for the site, etc.) and waste management solutions (recycling, incineration, landfilling), either itself or by contracting with other waste management companies, or public waste treatment operations for hazardous waste (SAKAB).

Most of the waste generated at Olofström is sorted on site, prior to collection, and using containers rented from Stena e.g. metal scrap, carboard and paper, plastics, emuslioners, used oils as well as other small streams of hazardous waste, etc. Clear instructions are given to workers and are also available in a waste sorting guidance handbook that has been developed by the environmental department (Lexe, 12 July 2006).

4.2 Running the assessment

In order to assess the relevancy of waste accounting for Finnveden's Olofström site, the following aspects will be reviewed in this section:

- Characterisation of the main production costs at Olofström and description of ths situation with regards to waste costs (4.2.1);

- Presentation of existing waste accounting and reporting practices (4.2.2), and recommendation with regards to the types of waste-related costs that would be relevant for Olofström to include in a future waste-costs performance indicator (4.2.3);

- Recommendations on how to initiate the change, report on and use a waste costs performance indicator, within the organisational context (4.2.4, 4.2.5 and 4.2.6).

The last two points were only covered to the extent allowed by the information that could be gathered from the company, given the unavailability of many staff members during the traditional holiday period in Sweden, as well as the time constraint due to the deadline for the handing-in of the Thesis project.

4.2.1 Characterisation of costs

4.2.1.1 Main production costs

The following information about the relative weight of different production cost categories in percentage of sales was received from Olofström's controlling department for the year 2005:

Ksek

2005		*% of sales*
Sales	554 670	
Material cost	308 630	*55,6%*
Total other costs	49 975	*9,0%*
Salary	129 252	*23,3%*
Incl in Total other cost	**49 975**	
Energy cost	*8 533*	*1,5%*
Maintenance (parts not labour)	*15 309*	*2,8%*

Figure 17: Sales and costs for 2005 at Olofström
Source: Nilsson, 1 September 2006

The most striking aspect is the very high amount (308 630 000 SEK) and share (more than 55% of sales) represented by raw material costs i.e. more than twice the cost and share of labour in production. As an initial comment, it can be said that this cost structure is likely to make Finnveden Metal Structures and its Olofström site a good potential candidate for RWA, as it has been outlined in the previous chapter that high raw material costs combined with low material efficiency increase the potential relevancy of cost accounting for waste.

With regard to the cost allocation methods used at Olofström, information collected from the Controlling department can be summarised as follows (Nilsson, 1 September 2006):

- Energy and general expenses are kept aggregated i.e. not allocated back to specific cost centres or processes;
- Labour is allocated to cost centres. There are about 20 of them at Olofström (e.g. environmental department, controlling, forklift drivers, etc.), including 12 in the production process itself;
- Cost allocation mostly does not go down to the level of individual products. The reason for this is that that many thousands of sometimes very small 'cells' (intermediate products to be used by the automotive industry) are produced, which makes detailed cost allocation very complex. It is believed that the benefits that would

be derived from making cost allocation more specific to products/cells would not be worth the increase in accounting complexity.

4.2.1.2 Waste as an income rather than a cash-cost

As per the table below, Olofström is in the uncommon situation of having waste collection and treatment as a net revenue. This is due to the combination of the big quantities of metal scrap generated during the stamping and pressing processes, and the high value of this scrap for recycling purposes.

Table 13: Olofström's waste collection, treatment and disposal costs and revenues

All figures in thousand SEK	January-December 2005		January-June 2006	
	Cost	Revenue	Cost	Revenue
Hazardous waste	527	-	199	-
Steel	-	15 106	-	10 926
Other metals	-	101	-	78
Other waste streams	141	-	124	-
Rent of containers	579	-	277	-
TOTAL	**1 247**	**15 207**	**600**	**11 004**
BALANCE	**-**	**13 960**		**10 404**

Source: Stena Gotthard AB, 2005 and 2006

The remaining of the assessment and recommendations will focus on steel scrap and omit other waste streams; this choice was made for the following reasons:

- Steel scrap represents the very big majority of the solid waste generated at Olofström in terms of tonnage, and, as shown by the table above, outweighs by far all other waste streams in terms of associated monetary flow;

- From a practical point of view, the generation of steel scrap in the production process is fairly easy to understand, which simplifies the analysis when intending to allocate various types of costs to waste.

It must be acknowledged that the particular waste situation at Olofström as well as the methodological choice of focusing on steel scrap will, at least partially, limit the transferability of results to other companies, especially if in a different industry. One could actually assume that the quantitative outcome of a waste accounting modelling at a given company will hardly ever be transferable at all, except maybe to a company with an almost identical cost structure and generating similar waste streams. However, the approach of evaluating to what extend waste accounting is relevant and the learnings of how to conduct such an assessment will be applicable in other cases.

Now, according to Olofström's Controller, the income generated by steel scrap in 2005 (15 105 587 SEK for 2005) is included in the site's total turnover of 554 670 000 SEK that year (Nilsson, 1 September 2006). Thus, the sale of steel scrap represented almost 2% of

Olofström's turnover, which gives an idea of the perverse incentive associated with the generation of this waste stream, when aggregating the income it generates with sales of actual finished products. This situation reminds of the vicious circle described in Section 3.2.3.2, where it was pointed out that the current definition of waste costs often prevents waste from being considered as a relevant cost to the business.

Some of the site's customers actually involuntarily participate in this vicious circle. Hence, some of Olofström's biggest customers, Volvo in particular, know the 'income' Finnveden is generating from its metal scrap. Thus, they ask to benefit of at least part of this income, wich Oloftsröm ends up having to share with them (Nilsson, 1 September).

The next sub-section (4.2.2) provides background information on the accounting and reporting information in place for data related to waste.

4.2.2 Current waste accounting and reporting practices

4.2.2.1 Absence of cost accounting for process waste

All Finnveden plants have certified quality and environmental managamenet systems in place:

- Quality management: All plants are certified according to the ISO quality management standard 9000. In addition, several are certified according to TS 16949, which is an automotive industry specific demand on quality management systems.

- Environmental management: All plants are certified according to ISO 14001.

The environmental coordinator pointed out that the prioritised environmental aspects are energy, hazardous waste and outside transportation to and from the plant. An additional environmental-related goal is set for defects and quality performance. However, her opinion is that material efficiency is an other aspect that would need to be looked at more. She actually believes it is actually likely to become a focus for Finnveden Group as a whole in a nearby future (Lexe, 12 July 2006). Based on the analysis of results from the empirical study presented in Chapter 3, Finnveden Metal Structures was placed on the 'Quality vs. waste accounting matrix' (refer to Table 10 on page 18 for the original table):

Table 14: Placing Finnveden on the quality vs. waste accounting matrix

		Cost accounting for waste			
		Quantities only	Wasted Raw Materials	Production costs	**TOTAL**
Cost accounting for defects	Quantities only	1	0	0	1
	Wasted Raw Materials	1	0	0	1
	Production costs	8 including **Finnveden**	3	2	13
	TOTAL	10	3	2	15

Finnveden is one of the eight companies having a comprehensive cost accounting for defects, but no cost accounting at all for process waste. In other words production costs are calculated for defective products and allocated to the so called ‘cost of poor quality’, while only quantities and cash costs of waste (cash income in the case of Olofström, although the cost associated with hazardous waste is considered separately) are accounted for for process waste.

4.2.2.2 Operational performance and internal environmental reporting

Various departments at Olofström prepare a ‘monthly operating summary’ jointly, providing nineteen performance indicators for the site’s operational performance.

Table 15: Olofström's 20 monthly indicators of operational performance

	Performance Indicator	Unit
1	Supplier rejection excluding metal coil	PPM
2	Number of rejection reported to supplier	ST
3	Customer rejection	PPM
4	Number of rejection reports from customers	ST
5	Cost of poor quality	%
6	Delivery performance supplier	%
7	Delivery performance customer	%
8	Average stock turn	Number of days
9	Average time for exchange of die	Number of days
10	Efficiency	%
11	Productivity	%
12	Operational profit	% compared to budget
13	Number of workplace accidents	ST
14	Short time absences blue collars	%
15	Short time absences white collars	%
16	Deployment conversation	%
17	Consumption of energy	Kwh/ton of goods produced
18	Non recyclable waste	Kg/ton of goods produced
19	Cost of off site transportation	SEK

Source: Adaptaed from Nilsson, 2006

The information contained in this table confirmes the observation that a ‘cost of poor quality’ is calculated and accounted for for defects, while process waste is not monetarised (cf. the cells highlighted in blue above). In addition to waste not being reported in terms of cost, it is even more interesting to observe that only ‘non-recyclable’ waste is considered in this monthly summary of operational performance. In other words, recyclable waste, among which steel scrap, is not included. A possible explanation for this could be the fact that is generates an income for the site as per the information presented in the previous section.

Given that it is not included in the monthly operating summary, environmental cost information has to be seeked elsewhere. It is included in the yearly internal environmental report entitled 'Miljönyckeltalsrapportering', prepared by the environmental department of each of Finnveden's three business units, and supplied to the Group's corporate environmental department. The report includes both data in terms of quantities (e.g. mega watts hour of energy and cubic metres of water consumed, tonnes of raw materials used, tonnes of waste generated and goods transported), as well as cost information.

These environmental expenses are classified between five selected key performance indicators, as presented in the following table:

Table 16: Environmental performance cost indicators at Finnveden Metal Structures

Performance Indicator	Total Expense for 2005 in thousand SEK
Hazardous waste	1 163
Waste handling/management	492
Environmental inspection	337
Environmental- education and consulting	15
Soil remediation costs	303
Total	**2 310**

Source: Finnveden Metal Structures AB Miljönyckeltalsrapportering 2005

The total environmental costs considered here for Metal Structures as a whole represent less than 0.5% of Olofström's turnover[14], which gives a partial explanation of why waste costs are currently not looked upon as an area of focus.

Now, all five cost indicators reported here are cash costs, not calculated ones. They account for money that the company is paying to external organisations. The 'soil remediation costs' for instance, represent the amount that the Metal Structures division had to pay after purchasing an existing site without running a proper 'environmental due dilligence'. Thus, such cost information cannot be considered as constituting a real cost accounting and reporting system. It is however an interesting attempt of implementing some sort of environmental accounting for internal management purposes, and could be built upon if trying to expand environmental cost information to account for 'calculated costs' as well.

The next sub-section (4.2.3) consists of a review of some waste-related costs and their potential relevancy for the Olofström site, the objective being to give an indication of the impact their inclusion would have if calculating a more comprehensive cost of producing steel scrap.

[14] The turnover for Metal Structures as a whole was not available. However, Olofström being by far the largest Metal Structure site, its turnover is an acceptable underestimation of the division as a whole.

4.2.3 Additonal waste related costs to be considered

4.2.3.1 The need to account for the true cost of wasted raw materials

As described in Section 4.2.1.2, steel scrap is viewed by the company as a source of income despite high and increasing raw material purchasing costs. Moreover, it seems like there is no incentive for Olofström to consider this waste stream as a cost to the business: it is the customer who pays for the steel wasted since 100% of the purchasing costs of raw materials, even if wasted, is allocated to finished product.

However, based on the currently highly inefficient use of purchased steel, the obvious way of initiating waste accounting would be to start by accounting for the purchasing price of the more or less 40% of steel coils wasted in Oloftsröm's production process. The table below gives an indication of the potential impact of doing so for the steel wasted in 2005 and during the first six months of 2006:

Table 17: Net cost of wasted raw materials for steel scrap for Olofström

Period of time	Tonnes of steel wasted	Revenue from sale of metal scrap in thousand SEK		Purchasing prices of raw materials in thousand SEK		Net Cost in thousand SEK	
		Per ton	Total	Per ton	Total	Per ton	Total
Jan.-Dec. 2005	10 674	1,415	15 104	6	64 044	**4,585**	**48 940**
Jan.-June 2006	6 070	1,8	10 926	6,7	40 669	**4,9**	**29 743**

It must be outlined that some of the figures used for the calculations are approximate:

- Based on the information collected during the interviews, the following averaged figures were retained for the purchasing prices of raw materials: 6 SEK per kilogramme (kg) for 2005 and 6.7 SEK per kg for the first half of 2006 (Lexe, 12 July 2006). In practice, steel prices are adjusted on a regular basis during the year, based on supply and demand on the liberalised international market;

- Moreover, all types and grades of steel and steel scrap have been aggregated and averaged when in reality, both the purchasing prices of steel as a raw material and its selling price as scrap vary depending on the specific grade and quality considered.

Despite these limitations, the calculations provide a good idea of the magnitude of the impact when starting to account for the purchasing cost of waste raw materials. Instead of being looked at as an income via its sale to Stena, the steel wasted during production and ending up as scrap appears to be a major net cost for Olofström: In 2005, it represented almost 9% of the site's 550 million SEK turnover.

Now, because those 9% are included in the pricing of the finished products, they do not appear as an issue, but it should be acknowledged that such high costs for wasted materials damage the price-competitiveness of the company.

Wasting steel is likely to cost Finnveden even more in the middle term with increasing raw materials prices. The current tension on international markets for many commodities and materials, due in particular to the continuously increasing consumption of China, has resulted in rising steel prices for Finnveden between 2005 and the first half of 2006 (+12%). Despite a proportionally higher increase in the price received from Stena for scrap (+27%), the net cost of wasting steel has increased by almost 7%.

Assuming that the increase in steel prices will be the same between 2006 and 2007 than it has been between 2005 and the first semester of 2006 (+12%), and that the price received from Stena follows the same pattern (+27%), the net cost of wasted raw materials for the first semester of 2007 could look as follow:

Table 18: Potential future net cost of steel scrap for Olofström

Period of time	Tonnes of steel wasted	Revenue from sale of metal scrap in thousand SEK		Purchasing prices of raw materials in thousand SEK		Net Cost in thousand SEK	
		Per ton	Total	Per ton	Total	**Per ton**	**Total**
Jan.-June 2007	6 070	2,29	13 900	7,48	45 404	**5,192**	**31 503**

This is about 2 million SEK more than for the first semester of 2006. Moreover, in this scenario, it is assumed that the volume of activity stays constant. If production increases, the net cost to the business will be even higher. If no measures are taken to improve material efficiency, the net cost for Olofström of generating steel scrap will continue to rise with both rising raw material prices and increasing production.

Thus, the opportunity cost of the status-quo is very high i.e. the money wasted on scrap does not only affect today's operational margin but also prevents investing in value adding activities for the future by the amount of the net cost calculated above. Such observations should enable to justify allocating human and financial resources to make a change happen as soon as possible.

Now, looking back at the fact that some of Olofström's customers ask to be awarded with part of the money that the site recovers from Stena, the question can be asked why those customers don't put pressure earlier in the 'value chain' instead, to force Finnveden to improve its material efficiency. Given the purchasing price of steel, and knowing that customers pay for 100% of the raw materials purchased, even if wasted by Finnveden, it is likely that customers will not accept paying for inefficiencies and wasted materials forever.

The scope and time allocated for the purpose of the research did not allow investigating the current competition intensity in the metal parts industry, but as in many other industries, it is probably increasing. With more and more pressure placed on companies to reduce costs in all areas of the business, such wastage as the one described for steel at Olofström will hinder the company's cost-competitivity more and more.

Cost competitiveness has actually been identified by Finnveden as one of its 'key success factors', with in particular many efforts made to increase the share of labour-intensive production in low-cost countries like China, and to a certain extent, Poland. Material efficiency, whether in Sweden or in relocalised production, has to be part of such cost optimisation efforts. It is however only likely to come in focus if viewing the real cost of material inefficiencies and wastage.

4.2.3.2 Relevancy of additional cost categories for process waste

As underlined a couple of times in this document, waste can mainly find its causes in quality issues or the production process itself. Defects and process waste are usually considered differently for various reasons, among which the amount of value-added that is included when reaching the stage of waste. This difference is particularly relevant in the case of Finnveden's Olofström production site:

- Defects have as much value added as products up to the stage where they exit the production process because of a quality issue. Thus, calculating production costs of defects is almost systematically relevant (labour, energy, machine use, production and administrative overheads, etc.). Moreover, the later the problem happens and/or is found out in the production process, the higher the value associated with the defective semi-finished or finished product. For instance, if the defect goes through the whole production process, it will have an identical value to a finished product. The cost of poor quality will then either account for 'total production costs', or for 'loss sales', the latter including lost profit margin in addition to production costs.

- For process waste, the decision on what costs to include is not as systematic as for defects. Allocating wasted raw materials to process waste appears to be relevant in many cases, especially in the case of Finnveden. Now, whether process waste also includes some value added in the same way as defects can be argued.[15] This is dependent both on the stage of the production process, as well as the manufacturing conditions under which process waste is generated. In practice, the question should be asked whether waste generation requires extra labour, energy and machinery use than in the case where the only output of the production would be the product itself? In other words, to what extent is process waste a 'cost driver'.

The table below briefly discusses the relevancy of allocating various cost categories to process waste in the case of Olofström: this includes production costs according to the definition of RWA given previously (such as labour, energy, capital and overheads), as well as additional cost types leading to FPCA and FCA. Considering all cost categories listed in Chapter 2 was done to be consistent with the methodology used since the beginning of the Thesis work. However, at this stage of the project, the knowledge gained enables to confirm the initial intuition that the theoretical concept with the most practical relevancy is RWA. Additional cost categories not covered by RWA are not quantifiable enough in order to be included in a simple enough calculation; this however doesn not imply they are of no relevancy for the company, as pointed out in the table.

Table 19: Assessing the relevancy of waste-related costs for Olofström

Type of cost	Comments	Degree of Relevancy
Internal waste handling and management costs	They are already included in the internal environmental reporting (a bit less than 500 000 SEK in 2005), but would have to be allocated more specifically to steel scrap	Medium

[15] Let's remind here that purchased raw materials do not contain 'added value' in themselves until they are transformed in a way or another by the purchaser during its production process.

Additional production costs (RWA)	Given very high proportion of steel being wasted, it is likely that it would be relevant to allocate some of the main production costs to the scrap generated, such as labour, energy, capital depretation, maintenance, etc.	High
Contingent costs	They are linked to the acquisition of existing production sites and land previously exploited; if a proper 'due diligence' is not conducted, the potential decontamination and liability costs can be very high; however, as the waste generated during the production process at Olofström only contains small fractions of hazardous waste, waste-related contingent costs can be evaluated as low	Low
Less tangible costs	It is likely customers will not accept forever to be charged for wasted materials in the price they pay for products; if Finnveden doesn't increase its material efficiency, the relationship with some of its customers might get damaged	High
External costs	External costs would only be relevant if taking a life cycle approach, in particular the resource depletion and global warming impacts of the production of steel coils purchased by Olofström	Low
Opportunity costs	They are very relevant for Olofström in both ways: (1) Try to improve material efficiency now to avoid future higher purchasing costs due to increasing prices on international markets; (2) Understand the total cost of generating steel scrap and what it represents in terms of value-adding activities that could have been invested in instead	High

The next table summarises an attempt to apply partially RWA at Olofström, by quantifying the real total production cost that could be allocated to the generation of waste:

Table 20: Total cost of the steel wasted in the stamping and pressing processes

All monetary data in thousand SEK	**Total amounts for 2005**	**% of sales**	**Allocation to steel scrap**	**% of sales**
Sales in 2005	**554 670**	**100%**	**-**	**-**
Raw materials costs	308 630	56%	48 940	9%
Labour costs	129 252	9%	20 496	4%
Overhead costs	49 975	23%	7 925	1%
Total costs	**487 857**	**88%**	**77 360**	**14%**
% of total costs	**100%**	**-**	**16%**	**-**

The above RWA calculations are limited in many ways, in particular

- The raw material cost allocated to steel scrap (48 940 000 SEK) is the amount that was calculated by the author earlier in this section, when assessing the net raw material costs of generating scrap. As previously acknowledged this calculation was partially based on rough estimations;

- The previously calculated net cost of wasting steel represents a bit less than 16% of the total raw material costs for 2005. This percentage was used as a basis for allocating labour and overhead costs to steel scrap as well. There is no particular reason or justification for having done so, except that the Thesis timeframe did not allow to get a deep enough understanding of the production process at Olofström in order to come up with an allocation method more faithful to the manufacturing reality.

Therefore, the above-outcome of the attempt to initiate RWA for steel scrap at Olofström should not be used for any other purpose than giving a very rough indication of the total cost of having generated 10 674 tonnes of scrap in 2005. The margin of error is impossible to assess but is likely to be high. A much more thorough analysis of the behaviour of, and drivers for the various cost categories under consideration would need to be run to be able to come with a an accurate figure.

4.2.4 A waste cost indicator in the organisational context

4.2.4.1 Convincing management

According to the Environmental Coordinator, the main reason why material efficiency is not a primary area of focus at Finnveden, is because information about waste materials is not translated in a 'business language' i.e. process waste is mostly considered as an environmental issue to be kept under control by making sure waste management is conducted properly (Lexe, 12 July 2006). In the case of Olofström, the fact that waste is a source of income rather than a cash-cost is an additional aspect that has to be fought against if trying to convince management and the organisation as a whole of the need to start accounting for waste as an indicator of inefficiencies costing money to the company.

Capturing attention of management should not be difficult here, given the amount of money at stake. It is more a matter of presenting the information in a way that will outline the issue in an obvious way, probably by putting together a 'business case' for engaging in waste accounting as a tool for improved material efficiency and cost avoidance.

Once management is on board, convincing production workers as well as other relevant employees (e.g. procurement staff) will be easier, as the arguments to support spending time and money on reducing wasted materials will be mainstreamed instead of the current situation where the organisation is probably happy with waste remaining a focus mainly for the environmental department. At this stage, the controlling departments will need to be involved in order to generate the data necessary to produce an appropriate cost performance indicator for process waste.

4.2.4.2 Reporting a relevant waste cost metric

The choice of the characteristics of an appropriate cost indicator for Olofström's wasted steel has to be made by answering two main questions:

- Which cost categories are worth being digged out of the accounting system in order to allocate a share to the generation of steel scrap?

- Where in the numerous existing information flows, will the newly created indicator fit?

With regard to the choice of cost categories to be included in RWA calculations, going beyond the inclusion of the purchasing price of wasted material will require a more thorough assessment of the role of steel scrap generation as a driver for costs that would not occur if less or no process waste was produced.

When it comes to deciding where to incoportate the new cost indicator in existing information flows and reporting procedures, a few possibilities can be viewed:

- Integrate waste cost accounting as an additional indicator into the previously-mentioned 'monthly operating summary': Doing so would have the main advantage of mainstreaming the issue of the cost of material inefficiency;

- Incorporate stricter quantified targets for raw material efficiency in production plans and costing based on typical and optimal wastage: This option is only relevant if it is possible to reduce steel wastage under existing manufacturing conditions. In other words, if the only way to improve material efficiency it to invest in new machinery, then setting stricter targets is pointless until such investments have been made. However, given the percentage of purchased steel wasted (more or less 40%), it is very likely something can be done about the way current operations are being conducted;

- Mimic the exisiting cost accounting for non-quality and/or merge quality and waste cost accounting to develop a metric for the 'total cost' of manufacturing inefficiencies: It has been pointed out earlier that defects and process waste often have to be treated differently, including from a cost perspective. In other words, the existing cost accounting for defects is unlikely to be directly transferable to wasted raw materials. However, there is a natural link between non-quality and waste steel as they are both signs of existing manufacturing inefficiencies. Thus, the possibility of allocating the responsibility of conducting RWA to the person already in charge of calculating the 'cost of poor quality' can be viewed;

- Add the calculated cost of waste as a sixth environmental performance indicator in the yearly internal environmental reporting: This is likely to be the easiest option to implement given the fact that the initiative of looking at the cost of waste in a more comprehensive manner was initiated by the Environmental Coordinator. However, incorporating the new cost indicator in environmental management and reporting has the main disadvantage of keeping wasted materials separate from operational efficiency measurements and management.

Additional possibilities can be viewed. In fact, the four options listed above are not exclusive and can be used complemetarily to each other, depending on the desired and optimal linkages between environmental management, quality management, cost accounting and production activities.

Independently from the choice that will be made, these departments will need to work more closely together anyway on the issue of material efficiency. Cross-functional links can be created via the development of joint working teams and training programs involving environmental and quality managers, line managers and controlling staff.

It was actually mentioned during the discussion with the Controller that meetings involving production supervisors and their teams as well as the Controller himself, take place each month for each of the five main 'areas' in the production facility (e.g. stamping, assembly). During these meetings, achievements and issues are discussed, and targets reviewed (Nilsson, 1 September 2006). One could imagine such meeting to be an appropriate occasion to discuss the cost of material inefficiency with the relevant 'production areas'.

4.2.4.3 Relevant applications and potential benefits

The newly created cost indicator can be used in two main areas: process optimisation, and investment appraisal. Moreover, it offers a good strategic fit with the key success factors Finnveden has identified as making the company competitive.

Motivate continuous improvement

According to Olofström Quality Engineer, work is being done to reduce steel scrap on a continuous improvement basis, by trying to reduce the number of defect products, and by incorporating material efficiency objectives when designing a new product and planning its production, involving mainly production supervisors and the logistics department (Svensson, 8 September 2006).

Waste accounting should be used to mainstream material use optimisation in this planning phase. Moreover, the amounts of money to be saved will justify spending time on making the stamping process more efficient if possible, for instance by reducing variability. Existing production methods should be reviewed to see if more of the raw materials can be used rather than wasted, or alternatively if less material could be purchased.

Hence, some work could be done as well on the procurement side, to ensure that materials are purchased in quantities that correspond more closely to the factory's real needs i.e. reduce the systematic buffer bought to ensure production will not be short with regard to the width of the steel coils. However, it was pointed out by all interviewees from Olofström that sourcing steel is getting more and more difficult, and that the site is often experiencing delays in deliveries from suppliers. This could limit the possibility to add an extra constraint on buyers at Olofström. The data generated by waste accounting can in any case be used as a strong motivator to tackle the issue of wasted steel in a more proactive way.

Justify investment in new machinery

The cost of generating steel scrap, as presented in the previous sections, should be used as an input to project and investment planning. It is very likely that the profitability of many potential investments would be greatly enhanced if accounting for the true cost of wasted steel. The cost of a new stamping machine was estimated by Olofström's Quality Engineer to range from 700 000 SEK to 2 000 000 SEK (Svensson, 8 September 2006). This is compared to a calculated annual net cost of almost 50 000 000 SEK for the 10 674 tonnes of steel wasted in 2005.

The equation is obviously not as simple as what it looks like. More than one stamping machine will be necessary, and the gain in material efficiency (percentage of steel wasted compared to the current 40%) might not be a big jump. Alternatives should however be considered, accounting for the potential costs (present and future) that could be avoided if wasting less raw materials when calculating pay-back time.

Strategic fit

From a less operational perspective, the benefits described above that Olofström could derive from waste accounting appear to fit well with three of the four factors that Finnveden has identified as a base of its success: 'operational excellence', 'cost competitiveness' and 'technology and innovation' (the fourth factor being 'growth and gloalisation'):

- Operational excellence ('quality and delivery performance'): Improving operational efficiency by minimising wastage is one of the main aspects of operational excellence. In addition, by reducing the amount of steel wasted, Olofström will need to purchase less, which could in turn release part of the current pressure of finding suppliers that can deliver the quantities needed in time. Since delays in the delivery of raw materials is an issue, the productivity of the site could also be positively impacted by this change. Thus, customer satisfaction is likely to increase, as Olofström will be able to deliver more products in time, while wasting less money on steel scrap.

- Cost competitiveness ('cost levels and capital utilisation'): Finnveden aims at having an optimal cost structure. This involves for instance seeking for new suppliers and relocating labour-intensive production to countries where labour is less expensive. Now, another area of focus for cost competitiveness is 'efficient capital utilisation', which is being rationalised in every aspect of the operation. Now, it could be argued that with the current amount of steel being waste at Olofström, machines and equipment are almost used as much to produce scrap than to produce finished products. Improving material effiency will not only allow the company to save money on the purchasing side, but it is likely to participate in improved capacity and human resource utilisation across all processes and departments.

- Technology and innovation ('skills and competence development'): Finnveden strives at using more efficient working methods to improve Finnveden's business proposition. 'Innovative power' and 'technological development' also place demands on ensuring that co- workers' expertise develops continuously. Accordingly, the Group conducts a number of training programmes with the overall aim of increasing skills, motivating employees and supporting co-operation and networking. As a cross-functional approach increasing the knowledge the company has about the way it operates, waste accounting fits well in this scheme.

The results from the case study presented above provide an indication of the potential usefulness of waste accounting, as well as the conditions under which it can be relevant. However, given the specificity of the company's cost structure (share of materials in the total production costs), as well as the high percentage of materials currently being wasted, it can be assumed that those results will have a limited transferability. General learnings can however be used in different contexts, such as the different options available when it comes to choosing an existing information flow where the waste cost indicator would fit best.

5 Conclusions

The following paragraphs will summarise the main findings of the research work:

- The first paragraph (5.1) provides answers to the sub-questions listed in Section 1.3;

- The next section (5.2) is devoted to answering the main research question i.e. *To what extent and under which conditions is it relevant, both from an environmental and economical point of view, and feasible for industrial companies to expand their definition of waste costs towards full cost accounting?*;

- The final two sections of the Thesis provide recommendations for the development of a consultancy service based on waste accounting (5.3), and give indications for potential future related academic research (5.4).

5.1 Characteristics of waste accounting

How are environmental and more specifically waste costs defined in the accounting and/or environmental management literature? Is there a consensus and/or most appropriate manner to define and classify costs related to the generation of waste by industrial companies?

Abundant literature describing and explaining principles and methods of environmental accounting is available. Specific literature on environmetal management and cost accounting is also well developed from a theoretical point of view, although this specific field is still fairly young. Case studies have been conducted, but usually with flaws limiting both the practical relevancy and transferability of results:

- Systematic relevancy of EMA is most often assumed, while cases when environmental accounting is a net cost to the business are not viewed;

- The usual aim is to generate and present full summaries of all environmental costs in a parallel information system to the existing ones. This appears to be too complex and difficult to legitimate in practice;

- Varying definitions and classifications of environmental costs are used, making it difficult to gain a clear understanding of how to initiate EMA in the industry;

- Little information was found specifically on waste-related costs. No thorough case studies focusing on cost accounting for waste were found during the literature review.

How do companies currently define and account for their waste costs? How big is the gap between this and the accounting concepts described in the literature?

According to the findings of the literature review and empirical study, the gap between theory and practice is wide. Although only consisting of 20 companies, the sample population allowed a pattern to emerge: Most companies/sites interviewed only account for the cash-cost associated with waste management, collection and disposal i.e. rent of containers for sorting, price paid for collection and treatment, eventual green taxes paid to authorities such as the landfill tax.

A small minority of the companies reviewed calculate a more comprehensive indicator for waste costs, including most often the purchasing price of wasted raw materials. Waste-related direct and indirect production costs and administrative overheads are most often neither tracked nor allocated to process waste.

Is what companies are doing the result of a thought process or of a lack of interest or focus, and is there a willingness among them to extend their current definition of waste costs to cover less obvious aspects such as direct and indirect production costs, or risk-related costs?

Most of the twenty companies and sites interviewed outlined the amount of work that has been and is still being done in order to minimise waste and associated environmental impacts. Most of them have good arguments not to consider waste accounting as a relevant tool, but in practice this view is often based on an underestimation of waste costs. Because waste is generally considered as an environmental aspect to be kept under control rather than the sign of inefficiencies in the manufacturing process, the true cost of generating waste is underestimated, which generates the following vicious circle: A company has no incentive to look into waste accounting given its current assessment that waste costs are low.

When asking the interviewees about the potential interest for their site/company to engage in cost accounting for waste, the willingness to do so was most of the time low. Because only one interviewe was conducted at each company, it is however impossible to ensure that the opinion expressed by the interviewee is representative. Moreover, telephone interviews did not allow to get a thorough enough understanding of each site's processes to be able to evaluate the effective need for improved waste accounting in a definitive manner.

Can a methodology be established to help a company decide the degree of complexity and comprehensiveness it should use when defining and accounting for its waste costs?

The initial intention of the Thesis was to try to develop a methodology that would allow approaching any given industrial company/site, to help it assess the potential need for improved cost accounting for waste. However, given the multiplicity of factors having an impact on the practical relevancy of waste accounting, it had to be acknowledged that a 'one size fits all' method is not appropriate. The approach drafted at the end of Chapter 3 was the highest level of detail that could be provided if trying to encompass all types of industries and companies. If seeking more detailed and 'hands on' recommendations, the scope of the analysis would have to be narrowed to a specific industry, group of similar companies, or even probably a site-specific review.

However, the general framework defined in Chapter 3 can be used as a starting point. It consists of the following five steps:

- Understand the industry: Preliminary preparation work should be conducted in order to gain basic understanding of the industry that the company is operating in, and in particular to identify driving forces for waste and cost reduction, typical cost structure, usual waste streams, and best practices in waste minimisation and prevention;
- Gather information and understand waste-related costs by conducting interviews in various departments (mainly environmental and quality management, controlling and accounting, production, and if possible, factory and upper management), gather production- and waste-related documentation (flow charts, environmental reports, summaries of defects and waste generated, etc.), and collect necessary cost data (both general cost data as well as available costing for environmental aspects, waste in particular);

- Analyse the information and identify specific needs based on, among others, the characteristics of the waste generated by the company, its cost structure, the potential similarities between cost accounting for poor quality and waste accounting, etc.;

- Develop a performance metric: choice of the characteristics of the indicator and of where it will fit in the organisational context;

- Recommend management applications, both for continous improvement and key decision-making such as project planning and investment appraisal.

Should waste costs actually be considered as so called 'environmental costs' or would it be easier to mainstream waste minimisation strategies by looking at them as production efficiency-related costs?

Only a minority of interviewees consider waste costs as environmental costs exclusively. For most of them, such costs should, at least partly, be considered as production costs. However, reporting on waste data (whether quantitie or costs) is usually included in environmental reporting at their companies/production sites, which keeps waste disconnected from performance management activities, Hence, companies have to move away from the 'environmental aspect' approach towards considering waste as a driver for additional costs. In any case, wste has to be translated into monetary terms in order to convince management of committing resources to improve the situation and try to find ways to minimise waste and waste-related costs.

If proven that there is a need to generate a more comprehensive performance indicator for waste-related costs, how should such a metric look like? Where does it fit in the organisational context and what type of application can it be used for?

Two main choices have to be made: the first one in terms of the categories of costs to be included when calculating a more comprehensive cost for waste, and the second one with regard to where the newly created indicator fits within the existing information flows:

Table 21: Choosing the characteristics of a cost indicator for waste

Characteristics of the indiactor	Relevancy and advantage
Choosing the cost categories to be included in the cost of waste	
Cash-cost	What most companies are currently doing; it only provides an incentive for waste reduction if waste treatment and disposal costs are high; it can even act as a disincentive in cases when the waste generated consists mainly of valuable recyclables that generate an income when sold
Purchasing price of wasted raw materials	Including this cost is very simple from a cost accounting point of view; the higher the material costs and the lower the current material efficiency, the more relevant it will be
Additional production costs (RWA)	A thorough analysis has to be run to understand to what extent the generation of process waste is a driver for additional production costs such as labour, energy, and maintenance; in many cases allocating a share of those production costs to waste rather than product output will be justified, making the cost of waste much more relevant than when only viewing its cash cost

Risk-related, reputational and other less-tangible costs (FPCA)	Likely to be mostly relevant for those companies producing hazardous waste and with a relatively high risk of pollution and contamination of local natural resources; moreover, as they have a high associated degree of uncertainity and are therefore often difficult to quantify, such costs are unlikely to be used within the scope of a 'practical' waste accounting; they would however have to be taken into account if looking at future potential waste-related costs
External costs (FCA)	Because of both their intangeability and the difficulty in quantifying them, they are of little relevancy for waste accounting, unless internalisation has been forced upon the company through a green tax for instance
Opportunity costs	This is not an additional type of cost but an alternative way of presenting the newly generated data; the use of opportunity costs is a very relevant educational tool, as it allows to outline the total amount of money that has been spent on waste generation instead of investing it in value-adding activities; in addition, opportunity costs can be used to describe the future cost of the status-quo i.e. how much money will the company continue spending on waste if no change is operated

Defining where the indicator fits best in the existing information flows	
Keep waste accounting informal	This could for instance consist of including waste cost data in joint meetings or workshops; but waste costs are unlikely to become a permanent focus by doing so
Add the indicator waste accounting indicator in the existing internal environmental reporting	This option is likely to be the easiest one to implement, but it will keep waste exclusively as an environmental issue disconnected from operational performance; it must also be outlined that environmental managers usually have limited knowledge in accounting
Merge quality and waste accounting	If done properly, this can generate a 'total cost of process inefficiencies'; it also provides consistency in the calculation method used even if the types of costs included vary for defects and process waste
Incoporate cost accounting for waste in production planning and performance evaluation	The use of pre- and post-production mass-balances or similar tools can be an efficient way of ensuring that the use of raw materials is according to plans; however, it will leave material efficiency in the hands of engineers unless appropriate cost data is added to quantitative information
Include the indicator in usual performance reporting streams e.g. balance scorecard, monthly operational summaries, etc.	This can be done by including waste costs in 'balance scorecards' or 'montly operational summaries'; this option has the main advantage of allowing to mainstream waste-related costs at the management level

The following two sections are aimed at providing elements of answers to the main research question: *Is cost accounting for industrial waste an economically and environmentally efficient tool?* However, no systematic quantitative answer can be given with regard to how much money can be saved and how much pollution and natural resource use can be prevented, thanks to the use of waste accounting. This is due both to the scope of the research excluding the impact evaluation of improvements and investments that can be justified using the information provided by waste accounting, as well as the fact that the definitive impact of waste accounting can only be evaluated on a company/site specific basis.

5.2 Factors affecting the relevancy of waste accounting

The table below provides a summary of the influence factors reviewed, along with their respective degree and description of impact on the relevancy of waste accounting for a given company or production site. The level of impact (second column) has been attributed mostly based on the empirical review conducted with 20 Swedish industrial companies, and to a certain extent the case study, also taking into account available literature when applicable.

Table 22: Summary of selected influence factors for waste accounting

Factor	Degree of Impact	Description of impact on the relevancy of waste accounting
Certified EMS	Low	Since almost all companies and sites reviewed have a certified EMS, this does does not seem to promote an improved cost accounting for waste in itself;
Environmental permit	Low	No correlation was found between the legal obligation to hold a permit and the level of waste accounting in place at companies reviewed
Size of the company/site	Low	Both ‘small’ and ‘large’ sites among the 20 companies reviewed have poor waste accounting ; the ones accounting for more than cash-costs are also of variable sizes
Current definition of waste costs	High	Current practices at most of the 20 companies reviewed show that the narrower the current definition of waste costs, the lower the incentive to look at waste as a relevant cost to the business; since most companies/sites seem to be only accounting for the cash-cost of waste, this is a main barrier
Cost accounting for poor quality	Medium	Based on the empirical study, accounting for the production costs of defects can in some cases be a good example to strive for for waste accounting; in some cases quality and waste accounting could actually be merged to provide a total cost of process inefficiencies
Data and resource availability	Medium	Based on the findings from the literature review and the interviews, scarce human resources and the potential complexity in digging out the required cost data can be obstacles to the implementation of improved cost accounting for waste
Quantity of solid waste	Medium	There is a likely positive correlation between the quantity of solid waste generated and the potential relevance of waste accounting; further data would be required from each of the companies to confirm
Types, causes and origins of waste	High	Based on the interviews conducted, one could say, at the two extremes and in a very simplified way, that waste accounting appears to be more relevant when hazardous material is handled and hazardous waste generated, and less relevant when the waste consists of organic by-products with little or no raw material content; however, no definitive answers can be given with regards to reusable waste and by-products; they have an ambiguous impact on whether or not a company/site prioritises waste reduction

Raw material efficiency and cost	High	Based on the interviews and case study conducted, it appears that the higher the material costs and the more raw materials are being wasted, the more relevant will waste accounting be; accounting for the purchasing price of the materials wasted can in some cases make waste costs skyrocket
Cash cost of waste	Medium	Having assessed the willingness to engage in waste accounting at each of the companies and sites interviewed, it appears that the higher the current cash cost of waste collection and disposal, the higher the likelihood of an interest in looking at waste-related costs in a more comprehensive way in the future; this is because high cash costs give a strong incentive to the company to look for ways to reduce those
Perception within the company of how it performs	Medium	Based on the qualitative answers received during the interviews, when staff is convinced that good work is already being done to minimise wastages, and that little can be done technically to improve further, one is likely to be faced with a high degree of resistance to change when trying to implement waste accounting, also because of the potential loopholes it might end up outlining

Only those factors selected for analysing the results of the empirical review are listed above. Now, additional factors, such as the potential role of customers (as in the case of Volvo for Finveden), can have an impact on the relevancy of waste accounting for a company/site. However, given the limited time available for the research, the scope of the analysis was voluntarily limited to some selected factors found in the literature as well as the ones mentioned by the interviewees.

Despite this limitation, the list above can be used as a starting point if wanting to conduct an initial screening of a company or production site in order to assess the potential relevancy of waste accounting. Other factors would obviously have to be considered depending on the specific company looked at.

It is also important to point out that this screening only gives an indication of whether or not it could be worth for a company to engage in a more comprehensive cost accounting for waste. Providing an accurate and quantified estimation of the profitability of waste accounting would require much more work (e.g. cost-benefit analysis). In some cases, being able to say in a definitive manner whether it makes economic sense to engage in it is unlikely to be possible unless a waste accounting trial is run.

The next section addresses the question of the economic, but also environmental efficiency of waste accounting.

5.3 Waste accounting, eco-efficiency and cleaner production

After studying the relevancy of waste accounting from different angles of approach, it can be asked whether it is an economically and environmentally efficient approach. In other words, what are the benefits that can be derived from implementing cost accounting for waste, and can doing so motivate and justify cleaner production activities?

5.3.1 A potential to reduce costs and environmental impacts

Cleaner Production refers to preventative approaches to producing goods and services with the minimum environmental impact given the existing technological and economic limits of doing so. It describes a 'win-win' scenario of decreased environmental impact and increased profitability and competitiveness. Now, evaluating the potential for waste accounting to be a tool for cleaner production implies viewing its potential applications. Based on the literature review, interviews and case study performed for the purpose of this research, the following applications and subsequent benefits of implementing waste accounting can be presented:

Optimise material efficiency on a continous improvement basis

By outlining the cost of existing process inefficiencies, waste accounting can motivate staff to view waste minimisation options in a more proactive manner, for instance:

- Achieve greater efficiency from raw materials in production, by optimising processes (e.g. changing the process flow or reducing variability). By doing so, the product output can be increased and/or the quantity of purchased materials reduced;

- Change procurement routines towards purchasing materials in quantities that correspond more closely to the factory's real needs; reduce the systematic buffer.

Influence key-decision making

In addition to participating in enhancing manufacturing performance on a continuous improvement basis, calculating the true cost of generating waste is likely to have a longer term impact on waste generation by influencing key decision-making:

- Make cleaner production investment more profitable as new machinery will allow to increase material efficiency and avoid the total production costs associated with wastage (waste minimisation and prevention in some cases);

- Encourage material substitution towards greener procurement: waste accounting can be used as an input in cost-benefit analysis by providing the real waste-related costs of choosing either one of the options (waste minimisation and prevention);

- Influence the design of products: with newly defined waste costs, material and waste minimisation targets could be incorporated in the product development phase in a more systematic way (waste prevention).

Less tangible benefits in the longer term

In the longer run, less quantifiable and tangible benefits can be captured by embracing waste accounting and using it as an input to decision-making in daily operations as well as project and investment planning and evaluation. Examples of such benefits include avoiding future and potentially higher disposal and treatment costs, reduce insurance premiums by reducing quanitites and hazardousness of waste, improve employee health and safety, reduce regulatory pressure and costs thanks to beyond compliance work, etc.

Now, the research has enabled to move a step forward in proving that it can be rational for a company to engage in cost accounting for waste, in particular as material effiency improvements will generate cost savings and environmental benefit, thus providing a 'win-win' situation. However, it has to be acknowledged that waste accounting cannot be used as a 'one-size fits all' tool, especially as it can prove to be a net cost in some cases.

5.3.2 A need to define and scale waste accounting properly

Cost accounting cannot be evaluated in isolation. Complex relationships with other aspects of the business (production, quality, purchasing, etc.) make it difficult to prescribe a specific construction for waste accounting. Its systematic relevancy should therefore not be assumed, especially as it can be difficult to draw general conclusions about the gains to be achieved. Company/site specific pre-assessments have to be run to be able to get an indication of what degree of waste accounting could be relevant, or, alternatively, to be able to recommend that it is actually not worth engaging in a more complex cost accounting for waste. There is no point collecting additional data for the sake of it; companies do not have time for this anyway.

If it is evaluated that there is an interest for a company to do some work on improving how it looks at its waste costs, it is necessary that the recommended cost accounting system is scaled in an appropriate manner, so that it feeds the characteristics and needs of the company/site. Accounting for the purchasing price of wasted raw materials might be the only appropriate change for some, while RWA will be the way to go for others. In any case, the relevancy of each additional waste-related costs should be assessed by understanding whether or not the generation of waste is a driver for additional costs i.e. costs that would not occur if the only output of the production process was the product itself. Only in that case will waste accounting be economically justified.

Factoring in other types of waste-related costs in a waste cost indicator beyond RWA is unlikely to be directly relevant for many companies, as calculating risk-related or external costs can often be a difficult and uncertain exercise. Moreover, they do not have a direct impact on the immediate profitability and productivity of the manufacturing process. However, in the specific case when a company is faced with potential future decontamination costs under liabaility rules, it would definitively make sense to view such costs.

One could argue that limiting waste accounting to internal production costs located within the ideology of profit, limits its ability to achieve sustainability beyond what is economically interesting for the company. Despite the fact that it does not quantify and incorporate social and environmental external costs, environmentalists should however not disregard this approach. It is true that this accounting does not challenge the existing company paradigms, one should also accept that pragmatism is the only way to get the private sector to 'buy in' concepts and approaches that are not forced upon it by regulations.

Moreover, the potential for waste accounting to achieve a reduction in environmental impacts should not be underestimated either. Given the current situation at most companies where no cost accounting for waste at all is in place despite big amounts of waste being generated, waste accounting is likely to result in waste reduction if implemented, by outlining that it is in the company's economical interest to do so. This in turn will reduce environmental impacts.

Hence, the implementation of waste accouting, as recommended throughout this document, should be seen as a pragmatic approach in moving one-step closer to sustainability. It can act as a strong motivator and change-agent, by providing a new angle of approach for waste generation. That is a shift away from the current situation where in frequent cases it is exclusively viewed as environmental issue, towards considering it as business cost having a relevant impact on the company's profitability.

Only by talking the language decision-makers understand and listen to, will it be possible to mainstream waste management beyond environmental preoccupations.

5.4 Recommendations for Natlikan Sustainability

If wanting to develop a service to companies in the area of environmental cost accounting, waste accounting in particular, the following comments can be made:

- The good news for consultancies is that the current level of environmental cost accounting at industrial companies is low, often even inexistent. Even more interesting for Natlikan is the fact that those companies that have expressed an interest in investigating the possibility of introducing waste accounting also acknowledge that they need external support to do so;

- Because waste accounting is not systematically relevant, at least not to the same degree, the approach should probably start by running an initial company or even site-specific evaluation. This would likely be be risk-based for the consultancy, as companies are not ready to invest time and resources before proven this could be economically interesting for them, unless they have an identified issues and needs in this area. In the latter case, selling a service that will participate in solving this specific problem will be easier and will require less preparatory work to convince management to spend money on it;

- If the initial assessment provides sufficient proof of the potential usefulness of waste accounting, then a service can be provided. It could consist of analysing to what degree of complexity it would be relevant for the company/site to implement it, making recommendations on how to introduce the new performance indicator, and giving directions in terms of useful applications and benefits to be derived;

- The final step of evaluating cleaner production options based on, among others, data generated by the newly implemented waste accounting procedures, and making the decisions to invest time and money in some of them should remain the prerogative of the customer itself, as it requires a much deeper and technical understanding of production processes and available options for improvement.

Now, since Natlikan's core business consists of providing company-specific registers of legal requirements as well as more pro-active 'busniess intelligence' advices, a possibility would be to develop an additional optional service to their customers, focused on the development of waste-related legislation, taxes, fees and subsequent waste-related costs.

5.5 Areas for further research

From an academic perspective, the research conducted can be deepened and supplemented in many ways, including:

- Running company- or site-specific case studies in order to specify further the approach drafted in this report, as well as to be able to prepare a thorough and quantified cost-benefit analysis of a potential introduction of waste accounting. This would include viewing on the one hand the potential uses and applications of the newly generated waste accounting indicator (short- and long-term benefits), and on the other hand the resources that would have to be dedicated to the development of waste accounting (mostly staff time), as well as those that would have to be spent on the potential applications of waste accounting (workshops and training, capital investments, etc.);

- Going beyond improving the definition of waste costs at a given company to promote, when relevant, the allocation of newly defined waste costs to specific production processes according to ABC principles. The benefits that can be expected from doing so are a higher degree of accountability for waste generated, with progresses being made to improve material efficiency and minimise waste in return.

Bibliography

Bebbington, Jan., Gray, Rob., Thomson, Ian. And Walters, Diane. (1994). Accountants' attitudes and environmentally-sensitive accounting. *Accounting and Business Research*, 24 (94), 109-121

Burrit, Roger. (2005). Challenges for Environmental Management Accounting. In P. Rikhardsson, M. Bennett, J-J Bouma and S. Schaltegger, *Implementing Environmental Management Accounting: Status and Challenges* (19-44). Dordrecht: Springer

Cleaner Production International LLC. (1998). Management Accounting: The Hidden Driver for Clean Production. [Online]. Available: http://cleanerproduction.com/Pubs/pubs/MgtAcctgandP2.html [2006, June 2]

Cooper, Robin & Kaplan, Robert S. (1992). Activity-Based Systems: Measuring the Cost of Resource Usage. *Accounting Horizons*, 6/3, pp. 1-12

Ecorecycle Victoria (now 'Sustainability Victoria'). (2001). Waste Wise Industry Advisor Tool Kit, Full Cost Accounting. [Online]. Available: http://www.ecorecycle.sustainability.vic.gov.au/www/html/487-full-cost-accounting.asp?intSiteID=1 [2006, June 2]

Environmental Management Accounting Research and Information Center (2006). Overview of Environmental Management Accounting. [Online]. Available: http://www.emawebsite.org/about_ema.htm [2006, June 22]

Envirowise. (2003). Increase your Profits with Environmental Management Accounting. [Online]. Available: http://www.emawebsite.org/library_results.asp?txtSearch=Envirowise&Submit=Search&start_year=1980&end_year=2005&pubtype=0&emauser=99&ematype=99&geogregion=99&since_m=1&since_y=2001 [2006, May 10]

European Commission - Environment Directorate General. (2003). Preparing a Waste Management Plan: A methodological guidance note. [Online]. Available: http://europa.eu.int/comm/environment/waste/plans/index.htm [2006, May 10]

European Environmental Agency. (2006). Topic Centre on Resource and Waste Management. [Online]. Avaiable: http://waste.eionet.europa.eu/definitions/waste [2006, July 3]

European Environmental Agency. (2006). Glossary. By-product. [Online]. Available: http://glossary.eea.europa.eu/EPER/B/By-product [2006, July 7]

Figge, Frank (2006, July 3). Telephone Interview. Professor of Corporate Social Responsibility, St Andrews University & Sustainable Development Research Centre

Finnnveden Group. (2006). http://www.finnveden.com/customer/templates/startpage.aspx?id=3&epslanguage=EN [2006, July 11]

Finnveden Metal Structures AB. (2005) Miljönyckeltalsrapportering 2005

Finnveden Metal Structures AB. (2005). Verkstadsindustrins och gjuteriernas miljörapport - Environmental report sent to authorities for the Olofström plant

Howes, Rupert (2004). Environmental cost accounting: Coming of age? Tracking organisation performance towards environmental sustainability. In Henriques, A. and Richardson, J. (eds) *The Triple Bottom Line: does it all add up?* (pp99-112). London: Earthscan

International Federation of Accountants (2005). Environmental Management Accounting. [Online]. Available: http://www.ifac.org/store/Details.tmpl?SID=1123595939318284 [2006, May 10]

Jurgensen, Anna (2006, May 19). Telephone Interview. Consultant, Deloitte

Lexe, Anne (2006, July 12). Personal Interview. Coordinator Environment and Work environment, Finnveden Metal Structures AB

Nilsson, Andreas (Andreas.Nilsson@finnveden.com). Controller, Finnveden Metal Structures AB. (2006, September 1). *Re: Finnveden controlling*. Email to Raphaël Jachnik (raphael.jachnik@gmail.com)

Nilsson, Andreas (2006, September 1). Telephone Interview. Controller, Finnveden Metal Strauctures AB

Projasek, Robert (1998). Practical Pollution Prevention: Activity Based Costing for EHS Improvement. *Pollution Prevention Review*, Winter 1998, 111-120

Stena Gotthard AB. (2005). Avfallsstatistik, Finnveden Metal Structures Olofström, Januari - December 2006

Stena Gotthard AB. (2006). Avfallsstatistik, Finnveden Metal Structures Olofström, Januari - Juni 2006

Svensson, Joacim (2006, September 8). Telephone Interview. Quality Engineer, Finnveden Metal Structures AB,

The Institute of Chartered Accountants in Australia (2003). Environmental Management Accounting. An introduction and case studies for Australia. [Online]. Available: http://www.icaa.org.au/tech/index.cfm?menu=317&id=A105716607 [2006, May 10]]

United Kindgom Environmental Agency (2006). Environmental Accounting Glossary of terminology and definitions. [Online]. Available: http://www.environmentagency.gov.uk/business/444251/444754/252614/250569/?version=1&lang=_e [2006, June 12]

United Nations Division for Sustainable Development. (2001). Environmental Management Accounting Principles and Procedures. [Online]. Available: http://www.un.org/esa/sustdev/publications/publications.htm#technology [2006, May 10]

United Nations Environmental Program Production and Consumption Branch (2001). Cleaner Production - Key Elements. [Online]. Available: http://www.uneptie.org/PC/cp/understanding_cp/home.htm#definition [2006, July 6]

United States Environmental Protection Agency. (2006). Glossary of Terms. [Online]. Available: http://www.epa.gov/epaoswer/non-hw/industd/gloss.htm [2006, June 20]

United States Environmental Protection Agency. (1995). An Introduction to Environmental Accounting as a Business Management Tool: Key Concepts and Terms. US EPA: Washington D.C.

Wasteonline (2006). The waste hierarchy. [Online]. Available: http://www.wasteonline.org.uk/resources/InformationSheets/WasteDisposal.htm [2006, July 6]

Abbreviations

ABC	Activity Based Accounting
FCA	Full Cost Accounting
FPCA	Full Pivate Cost Accounting
EA	Environmental Accounting
ECA	Environmental Cost Accounting
EEA	European Environmental Agency
EFA	Environmental Financial Accounting
EMA	Environmental Management Accounting
EMARIC	Environmental Management Accounting Resource and Information Center
EU	European Union
GAAP	Generally Accepted Accounting Principles
IFAC	International Federation of Accountants
OECD	Organisation for Economic Cooperation and Development
RWA	Residual Waste Accounting
SEK	Swedish Kronor
SME	Small and Medium Size Enterprise
TCA	Total Cost Accounting
UK	United Kingdom
UNDSD	United Nation Division for Sustainable Development
US EPA	United States Environmental Protection Agency

Appendix I: List of interviews conducted

Date	Interview Type	Company	Name	Position
May 17	Telephone	Lantmännen Mills	Camilla Crook	E&Q Manager
May 17	Telephone	Findus	Anna Roslund	Quality and Industrial Development
May 18	Telephone	Volvo Trucks	Lars Mårtensson	Corporate E&Q Manager
May 19	Telephone	Gambro	Jerker Åkesson	Production Director
May 19	Telephone	Lyckeby	Christer Karlsson	Corporate E&Q Manager
June 13	Personal	Skanska	Ulrika Hammargren	Environmental and Waste Manager
June 14	Telephone	Expancel	Eva Löfstrand	Environmental Coordinator
June 15	Telephone	Hydro Polymers	Anders Rydbom	Environmental Engineer
June 16	Telephone	Volvo Trucks	Kjell Arne Haggstrom Sven-Erik Tjärnström	Environmental Manager Accountant
June 19	Telephone	Ericsson Power Modules	Eva Andblom	EHS Coordinator
June 20	Telephone	Norrmejierier	Olle Sjöstedt	Environmental Manager
June 20	Telephone	Seco Tools	Binella Nezic	Environmental Coordinator
June 20	Telephone	Holmen Paper	Leonard Dahlberg	Quality Engineer
June 21	Telephone	Trelleborg Protective Products	Karl-Erik Karlsson	Environmental & Quality Manager
June 21	Telephone	Kraft Foods	Mary Envall	Environmental Coordinator and Lab. Manager
June 22	Telephone	Powerwave	Mikael Jägroth	Quality Engineer
June 22	Telephone	Marbodal	Per Lindblad	Environmental and IT Manager
June 22	Personal	Amcor Flexibles	Sören Samefors	EHS and Real Estate Manager
July 4	Telephone	Finnveden	Anne Lexe	Environmental Coordinator
July5	Telephone	Trelleborg AVS	Pia Rohne	E&Q Manager

Appendix II: Questionnaire used for the interviews

<u>SECTION 1: Information about the interviewee</u>

1) What is your position in the company?

2) How long have you been working for the company?

3) What are your duties with regards to environmental management, and more specifically waste management?

<u>SECTION 2: General information about the production site</u>

4) How many employees work at your site?

5) What products are produced at your site?

6) What are the main production costs?

7) Do you have a certified (e.g. ISO 14001, EMAS) or informal environmental management system in place?

8) What is/are the main environmental issue(s)?

9) Do you have to hold an environmental permit? If yes, what category i.e. A, B, or C?

10) Has there been any outstanding environmental initiative(s) recently?

<u>SECTION 3: Information about the waste streams generated during the production process, and the management of this waste</u>

11) What are the different streams/types of waste generated during your production process and what is/are the main one(s)?

12) What is the main source of waste: process waste (non-product output) or defects (out of spec semi- or finished-products)?

13) What is the main cause of waste: low quality of raw materials, type technology and equipment used, operating procedures that could be improved, etc.?

14) Has the quantity of waste generated per unit of product/output increased or decreased over time?

15) Do you have specific waste minimisation objectives and targets?

16) Do you treat your waste on site?

17) Do you separate waste on site? If no, why? If yes, how?

18) Is your waste mostly being:

a. Reused internally or by another industry as a by-product;

b. Recycled (materials recovery);

c. Incinerated (energy recovery), or

d. Disposed off (landfilled)?

19) Is waste collection and treatment by your waste contractors a cost (e.g. case of waste being incinerated or landfilled) or an income (e.g. case of by-products, valuable recyclables, etc.) for your site?

20) Do you get regular data from your waste contractors about the quantities of waste they collect from you? Is this information broken down by waste types/streams?

SECTION 4: Information about the current accounting and costing for waste

21) Does your site use a so called "mass balance" to account for and balance materials entering and leaving the system/site?

22) Do you know whether your company is using a specific cost accounting methodology e.g. Activity Based Costing (ABC), Life Cycle Assessment and Costing (LCA and LCC), Total Cost Assessment (TCA)?

23) Do you personally consider waste costs as so- called 'environmental costs' or 'generic production costs'?

24) How does your quality management system account for the cost of defective products?

25) Are waste costs included in your management accounting and reporting system? If yes, what types of costs are included in the calculation? Has this changed over time?

26) Which waste cost category does your site identify as the biggest e.g. disposal costs, lost raw materials, indirect labour and energy costs, etc.?

27) What cost allocation method is used to account for indirect costs e.g. are they classified as overhead costs?[16]

28) What do you think are the main drivers/reasons for the choice of the existing managerial accounting procedure used for waste costs?

[16] Overhead costs: Expenses of a business which are difficult to attribute to any specific business activity, but are still necessary for the business to function. Examples include rent, utilities, and insurance.

SECTION 5: Interest in expanding the current definition of waste costs

29) What is your opinion about the current definition of waste costs at your site?

30) If not already done, would it be interesting for your site to include additional types of costs such as indirect costs, risk-related or even external costs? If no, why?

31) If yes, what would be the main benefits and barriers if trying to implement a more complex accounting system for waste costs?

SECTION 6: Development of an internal performance indicator for waste costs

32) How are waste costs being reported internally i.e. how often, and to whom?

33) Is the reporting of waste costs linked to the traditional management accounting, the quality management, and/or the environmental management system?

34) Do you think the current accounting and reporting procedure for waste costs enables to manage waste in an appropriate manner?

35) Do you think it promotes waste minimisation?

36) Do you think it enables to justify cleaner production investments e.g. new technology reducing process inefficiencies and losses?

37) Are there other environmental cost or eco-efficiency indicators included in your internal accounting and reporting procedures e.g. raw materials, energy?

SECTION 7: Summarising results

38) Each of the cost categories listed in the table below can be included when calculating the full cost of the waste generated. For each, can you please:

A) Say whether this type of cost is currently accounted for when calculating the cost of waste (yes/no);
B) Say whether your site/company would have an interest in including this cost type in the future (yes/no);
C) If possible, give a reason for having interest or not in including this cost type.

Cost category	Examples of costs	A	B	C
Waste disposal costs	Price paid to waste contractors, Landfill tax, Etc.			

Internal handling and treatment of waste costs	Labour, Energy, Water, Depreciation of waste treatment and storage equipment, Etc.			
Cost of wasted raw materials	Raw materials purchase price, Replacement cost			
Direct production costs	Labour and energy up to the time it becomes waste, Etc.			
Indirect production costs	Maintenance, Depreciation of extra production capacity needed to accommodate the waste generated, Etc.			
Contingency costs	Potential liabilities in case of soil, water or air contamination, Higher insurance premium due to hazardous waste, , Etc.			
Less tangible costs	Image and stakeholder relationship damage, Etc.			
Opportunity costs	Money spent on waste that could have been invested in productive and value adding activities, Cost of future more stringent waste legislation, Etc.			
External costs	Health costs, climate change/global warming impact, Depletion of resources, etc.			
Additional suggestion				