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ECO-EFFICIENCY IN THE MANUFACTURING OF STRETCH WRAPPING MACHINES

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EKOTEHOKKUUS KÄÄRINTÄKONEEN VALMISTUKSESSA

Tämän opinnäytetyön toimeksiantajana toimi Oy M. Haloila Ab. Työ oli tarkoitettu auttamaan yritystä sen ympäristöasioihin liittyvissä toiminnoissa. Opinnäytetyöllä oli kaksi tavoitetta: luoda työkaluja Haloilalle ympäristösuorituskyvyn mittaamiseen ja löytää sen toiminnasta yksittäisiä parannuskohteita ekotehokkuuden saralla.

Tutkimuksen teoriaosuuden tavoitteena oli antaa yleiskuva ympäristöasioiden hallinnasta nykypäivän teollisessa ympäristössä. Lisäksi luotiin erillinen katsaus pakkausalan ekotrendeihin.

Teoriaosuudessa esitellyn pyramidimallin avulla tehtiin analyysi Haloilan ympäristöasioiden hoidon nykytilasta. Lisäarvoa opinnäytetyölle luotiin tekemällä arviointi Haloilan lähimpien kilpailijoiden aktiivisuudesta ympäristöasioissa.

Opinnäytetyön ensimmäinen tavoite saavutettiin työssä esitellyn ekokompassin avulla. Se kertoo tehtaan ympäristösuoriutumisesta viidessä eri ympäristövaikutusluokassa. Toiseen päämäärään päästiin keskittymällä vain yhteen tehtaan toiminnan osa-alueeseen: rakennuksen lämmitykseen käytettävään teknologiaan. Molempiin asiakokonaisuuksiin sovellettiin ekotehokkuusajattelua.

Toimeksiantajalle ehdotettiin neljää toimenpidettä, joiden katsottiin hyödyntävän yritystä kun se pyrkii saavuttamaan ”ympäristöedun” kilpailijoihinsa nähden ja mikä tärkeintä, kun se pyrkii vahvistamaan asemaansa maailman johtavana käärintäkoneiden valmistajana.

Työn lopussa annettiin ehdotuksia jatkotutkimuksen aiheiksi. Ne tähtäsivät sekä tämän opinnäytetyön aloittaman työn loppuunsaattamiseen että ekotehokkuusajattelun viemiseen yhä syvemmälle Haloilan valmistamien käärintäkoneiden eri elinkaaren vaiheisiin.

ASIASANAT:

Ekotehokkuus, hiilijalanjälki,materiaalitehokkuus, käärintäkone.

BACHELOR´S THESIS | ABSTRACT
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ECO-EFFICIENCY IN THE MANUFACTURING OF STRECH WRAPPING MACHINES

This study was commissioned by Oy M. Haloila Ab to support their work on environmental matters. The two primary goals of the thesis were to create tools for measuring environmental performance for Haloila and to find specific targets of improving eco-performance.

The theory section was aimed to give a general look into the world of environmental aspects in the business life today. To reinforce the theory sections yield for Haloila, a section covering the current eco-trends in the packaging industry was added.

An analysis of the current environmental responsibility situation of Haloila was conducted with the help of a pyramid model presented in the theory chapter of the thesis. For added value a brief look into the environmental activity of Haloila´s closest competitors was included.

To fulfill the first goal of the thesis an eco-compass was introduced as a way of monitoring the factory´s environmental performance on a yearly basis in five environmental performance categories. Work revolving around the second primary goal was focused on one area; the technology used for heating the factory. Both objectives of the thesis were met by adapting an eco-efficiency mindset.

Four actions in total were proposed to Haloila so that it can get the work started on gaining the environmental edge over its competitors and, more importantly, to reinforce its status as a world leader in the production of stretch packaging machines.

At the end of the thesis suggestions were made to guide future research on environmental issues at Haloila. They aim to finalize the work started by this thesis and to take the eco-efficiency philosophy even deeper in the different life cycle stages of Haloila products.

KEYWORDS:

Carbon footprint, eco-efficiency, material efficiency, stretch wrapping machine.

TABLE OF CONTENTS

PICTURES

FIGURES

TABLES

1 INTRODUCTION

The thesis is conducted for a Finnish company Haloila (full name Oy M. Haloila Ab). Haloila is a part of the international ITW (Illinois Tool Works) group. Haloila has production in two countries, Finland and Bulgaria. This study focuses solely on the Finnish production site.

Haloila is one of the world's leading pallet wrapping manufacturers. The majority of its products are exported, mainly to Europe (Wikipedia 2012). Haloila´s factory, shown in Picture 1, is located in the town of Masku in South Western Finland. Haloila has been developing and producing semi and fully automatic stretch wrapping machines in Masku since 1976 (Haloila 2011b).

Picture 1. Haloila factory, located in Masku, Finland (Haloila 2011b).

As a world leader in its field of business, Haloila needs to constantly improve its performance in all aspects of its operations to keep up with increasing demands from different interest groups. One area where companies´ performance is constantly more and more challenged is the environmental sector. This thesis focuses on providing tools for Haloila for its work on environmental issues.

1.1 Haloila´s Products

Haloila develops and manufactures semi- and fully automatic stretch wrapping machines for industrial use. It has clients of various sizes and from different areas of the business world. Machines are sold to companies operating in, for example, consumer goods, construction and logistics businesses (Haloila 2011b).

Octopus is Haloila´s most recognized trademark. Octopuses (apart from the Compact model) are fully automatic pallet wrapping machines. The first Octopus was delivered to a customer in 1983 (Haloila 2011b). By 2012 over 4,000 Octopuses have been manufactured (Haloila 2011b). Picture 2 shows one example from the Octopus model range, the CTS.

Picture 2. Octopus CTS stretch wrapping machine (Haloila 2011b).

Haloila´s Octopus production in 2011 amounted to 172 units. 171 of them were manufactured in Masku, Finland and one in China.

Octopus is always a tailored product. All the models in the Octopus lineup have several extra options available to them and when necessary, they are further customized through mechanical and electrical design work to suit individual customer needs.

Haloila also produces semi-automatic Cobra stretch wrapping machines in its Masku factory. A Cobra machine is shown in Picture 3. 35 units of Cobra III machines manufactured in 2011 accounted for all non-Octopus production during that year in Masku.

Picture 3. A Cobra stretch wrapping machine (Nurminen 2009).

The Cobra range is a standardized product family with only a few extra options available. The customer cannot have a Cobra machine tailor fitted to optimally suit its needs in the same manner as in the case of the Octopuses.

Of the total 206 stretch wrapping machines manufactured in Masku in 2011, 83 % were Octopuses and the remaining 17 % Cobra III`s.

1.2 Mission and Vision

Haloila has the following mission (Haloila 2011b, 1):

> We create technological solutions and services to protect our customers´ products.

The Vision of Haloila is phrased as follows (Haloila 2011b, 3):

> We aim to be a valued partner to our customers as a global leader in the production of stretch packaging machines for pallet loads and as a service provider.
>
> - Customer valuation is generated by our outstanding quality, expertise and reliability.
> - Our leading position is based on the innovative and active consideration of the changing needs of our customers.
> - We aim to make our support network global.
> - Services are an integral part of our activities. They cover the entire life cycle of our products, from design, implementation, maintenance and upgrades to the design of a new product.

Neither the mission nor vision statement of Haloila has any clear environmental indications. However, in its vision Haloila states active consideration of the changing needs of its customers. This, as this thesis will indicate, will in some cases mean considering the customers´ ecological ambitions, most likely even more so in the future.

2 GOAL OF THE THESIS

This study focuses on the production phase of Haloila´s operations; more specifically the factory building. What comes in and exits the factory is thought to be a close enough rendition of the situation. This confinement of the subject is presented by the area left inside the red oval in Figure 1, modified from The Finnish Environmental Ministry´s presentation on material efficiency in a product´s life cycle (Valtion ympäristöhallinto 2012).

Raw materials, energy and fuels enter the factory building. Out of the factory come products and by-products. Their environmental impacts are calculated with the help of Haloila's own reporting systems and the methods presented in this study.

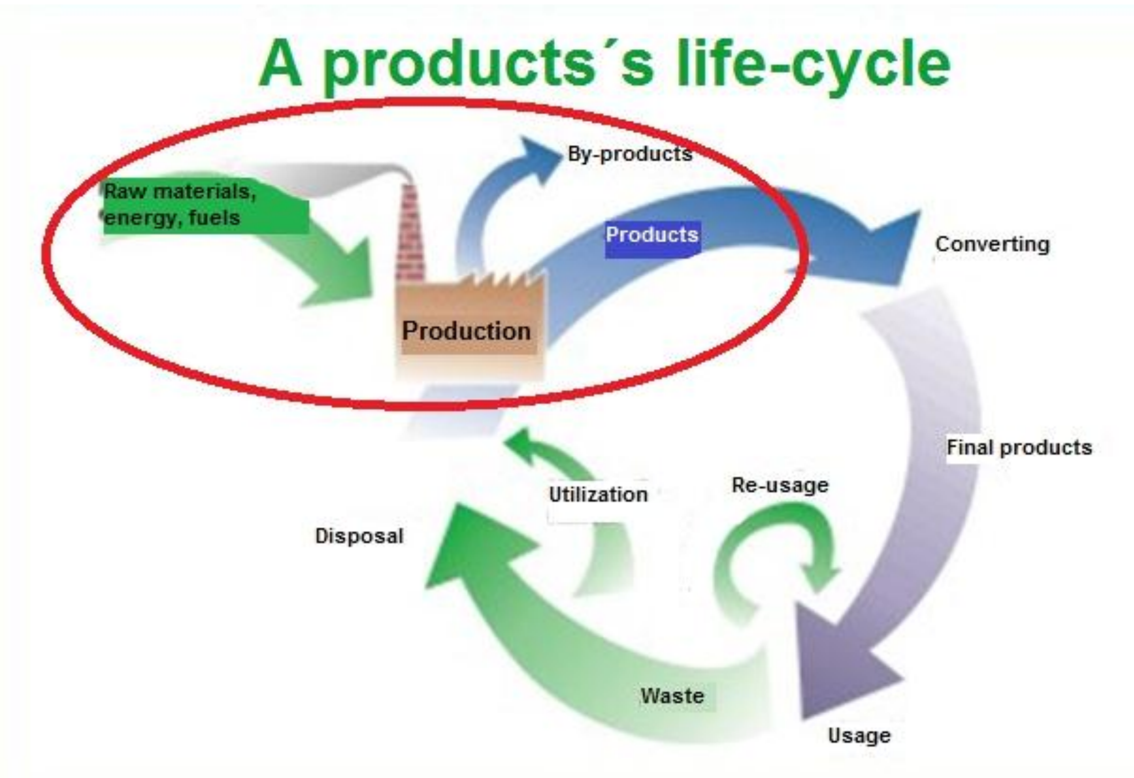

Figure 1. Focus point of this thesis in a products life cycle (modified from Valtion ympäristöhallinto 2012).

Naturally this approach is neither environmentally nor production wise perfect. Many non-production activities, such as design work and service spare parts warehousing and shipping, takes place inside the Masku factory. This thesis does not separate the environmental effects of production and other activities at the factory. This simplified approach was chosen because the main goal of this thesis is to create something new, rather than spend the majority of the time studying the already existing. Hopefully, this will help preserve as much of the efforts towards innovation inside the two main goals of this thesis as possible. These are presented next.

2.1 Creating Measuring Tools

The primary goal of this study is to create tools for measuring environmental performance. The ability to measure environmental performance will accomplish two things: firstly, it will offer Haloila the possibility to keep track of their eco-performance and secondly, it will give the already ecologically aware company something tangible to support their sales and marketing efforts in “green” values.

The environmental performance measuring tools to be used will be chosen after a literature survey. They will monitor areas that have an actual impact on environmental performance and that are relatively easily monitored, ideally with reporting methods already existing within the company.

2.2 Finding Targets for Improvement

The secondary objective of this thesis is to find and point out areas in the operation of the factory where environmental performance could be improved and to offer solutions for achieving improved results in them.

Improvement suggestions are first evaluated economically. Only after a positive signal from the profitability assessment is a more detailed ecological evaluation performed utilizing techniques presented in this thesis. This process ensures compliance with the statement also presented in this study that all environmental performance enhancing actions in a business environment must also be financially viable.

In the best case scenario, implementing the changes presented in this section would have such a positive effect on the eco-performance of the Haloila factory that it would be perceptible with the created tools for measuring environmental performance.

3 ENVIRONMENT AND INDUSTRY

The theory section of the thesis begins with a general view on the benefits of adopting an environmental outlook on doing business. A deeper insight on the issue is gained by focusing on some of the biggest trends in both the corporate eco-sector in its entirety and the packaging sector specifically.

Environmental strategies are a way of increasing a company's competitiveness and creating shareholder value based on sustainable competitive advantages. They are a way of responding to growing environmental awareness and expectations, as environmental concern is being increasingly driven by the market, not only the regulators. (Strannegård 2000.)

An environmental perspective can be seen as a legitimate threat management tool. When taking an active attitude towards environmental issues, a company can be more ready, for example, for changes in legislation and demands or inquiries by non-governmental organizations (Esty and Winston 2006).

Furthermore, adopting a greener mindset will specifically benefit small and medium sized enterprises (SME) doing business with large companies. Large corporations are often already involved with corporate social responsibility issues, including environmental responsibility. SMEs will have to meet the standards of the sometimes aggressive auditing programs run by their bigger scale clients more and more often. (Esty and Winston 2006.) It is not only in the future, when large scale companies will start to demand proof of sustainability from their suppliers, for example in the form of publicly reported sustainability goals (Johnson & Johnson 2011), for it is already starting to happen.

Large-cap companies that have adopted socially responsible policies, eco-efficiency in particular, outperform their ecologically less active competitors when comparing their performance in the stock market (Derwall et al 2005). This affects the field of clientele with which suppliers such as Haloila operate and the demands arising from it.

Finding areas where to improve companies´ environmental performance can lead, not only to being able to meet the demands of stakeholders in the long run, but also to money saving innovations that benefit the company almost immediately. This can be achieved for example by reducing material usage at the product´s manufacturing stage or running the daily operations with less energy used. This approach is especially beneficial and realistic for SMEs, which can be more agile in their maneuvers than their bigger competitors. (Esty and Winston 2006.)

To summarize, environmental strategies can be profitable both through reducing costs and by increasing sales opportunities: by creating a sustainable competitive advantage. Especially when taking a long-term perspective on the matter, investments in green rarely go wrong. (Strannegård 2000.)

The next chapters provide an overview on the major environmental issues in the industrial scene today. Four common environmental concepts are chosen for separate evaluation: environmental responsibility, life cycle thinking, eco-efficiency and carbon footprint.

The concept of environmental responsibility is a whole mindset bringing environmental issues into the business environment. The next three are tools that are used when a company has chosen to take the environmental responsibility road. These four items are certainly not the only popular notions in the environmental strategizing sector, but they are perhaps the most elementary.

Finally, a more specific tool is introduced, suiting the needs of the primary goal of this thesis, environmental performance measuring. The polygon model offers a way of monitoring a company’s eco-performance in multiple environmental performance categories in an effective manner.

3.1 Environmental Responsibility

Companies worldwide are taking an increasingly more active role in environmental, social and economic responsibility issues. Together these three dimensions, environmental, social and economic, form the field of sustainable development (Penttinen 2010; Finnair 2011). Often a company will report its performance in all of the three sections but focusing only on one aspect, usually environmental responsibility is also possible.

While a company´s method of pursuing environmental responsibility is ultimately its own decision, a few key ecological elements are usually present. These are emissions, waste, use of resources and environmental incidents (Bayer 2010). How the individual companies emphasize these elements and how they act to decrease their business´s environmental impact in them is largely decided on a company level.

The same applies for this thesis. Compliance with every possible environmental aspect is not a goal or even a possibility with the resources available for this study. By focusing on a few key areas arising from the current trends in environmental responsibility, it can be assured that whatever improvement is reached, it is in a sector that has a strong backing by the existing corporate eco-thinking.

Global Reporting Initiative

An emerging sustainability reporting framework going by the name of Global Reporting Initiative (GRI) is setting out to bring one standardized way to manage corporate social responsibility reporting, including environmental responsibility reporting. GRI has laid out Key Performance Indicators (KPI´s) that measure the environmental, economic and social performance of a company. (The Coca Cola Company 2011.)

Global Reporting Initiative is gaining popularity amongst the large multinational and national companies (Bayer 2010; Finnair 2011 ; Johnson & Johnson 2011; The Coca Cola Company 2011). Therefore its policies and demands will most likely sooner or later affect the smaller companies that act as suppliers for large enterprises. At minimum, it offers thought out guidelines for environmental policy making for companies of all sizes.

The ecology section of GRI covers in total nine environmental performance indicator aspects. These are:

- Materials
- Energy
- Water
- Biodiversity
- Emissions, Effluents and Waste
- Products and Services
- Compliance (laws and regulations)
- Transport
- Overall (GRI 2011).

Each aspect is further dissected in the GRI indicator protocol set. While the goal of this thesis is not to start a GRI based reporting system at Haloila, the protocol does offer a thorough set of principles that help to further guide the focus of this thesis in the right areas.

3.2 Life Cycle Thinking

Life cycle thinking in essence means analyzing the impact a product (physical product or a service) has on the environment during all of its life cycle stages: from the extraction of resources, production of materials and product parts, production of the product itself, to the use of the product and finally, the products “afterlife”, whether it involves reusing, recycling or final disposal. (Guinee 2002.)

The actual analysis of these phases is often referred to as Life Cycle Assessment (LCA). Because of the enormity of a full scale Life Cycle Analysis and the need to have uniform ways of conducting such a demanding assessment, standards have been created to guide organizations in their LCA work.

The ISO 14040 standard created by the International Organization for Standardization defines the requirements of a Life Cycle Assessment (Finnish Standards Association SFS 2006a). Its goal is to make environmental analyses more uniform both in techniques used and reporting forms.

According to the standard LCA is the evaluation of a product´s environmental aspects and potential environmental impacts of a product through its life cycle, from gradle to grave. A full Life Cycle Assessment conducted in the manner promoted by ISO 14040 is an ample task. The standard does however provide a good overview on the subject that is one of the key elements in the area of corporate environmental responsibility.

The ISO 14044 standard further defines the methods of conducting a Life Cycle Assessment. Where the 14040 tells *what* an LCA is, the 14044 tells *how* it is done. It has the same structure as the 14040, it only goes much deeper in its instructions. (Finnish Standards Association SFS 2006b.)

As this thesis focuses strictly on the production phase of Haloila´s activities, the thesis can be seen as part of a life cycle assessment on their products. Also, a mindset where the environmental impacts of individual decisions are considered in a life cycle manner is urged to be embraced by all decision making quarters at Haloila. Further LCA work and integration is to be done outside this study, as this thesis does not go deeper into this particular subject.

3.3 Eco-efficiency

While the first decade of the 21st century was seen as the decade of economic growth, the second decade is projected to being the decade of eco-efficiency, a decade of producing more from less. By adopting a more from less culture, a company can use less materials and/or resources in its production and hence save money while also working more sustainably from an environmental aspect. (Mutanen 2009.)

Eco-efficiency is a key factor in corporate sustainable development as it covers two (ecological and economic) of three dimensions of sustainable development. It is a management strategy that promotes more efficient production processes and at the same time decreases resource use, waste and pollution. (Penttinen 2010.)

Eco-efficiency can be seen as a business link to environmentally sustainable development of corporate policies (Erkkoa et al 2003). In practice, eco-efficiency is the division of a products economic value by its environmental impact (Helminen 2000; Erkkoa et al 2003; Bayer 2010). The larger the value obtained from the division, the better the eco-efficiency of the examined subject. Ideally this means that more money is made with lesser environmental impacts.

Just as the life cycle assessment, the concept of eco-efficiency will benefit from a globally standardized procedure. ISO 14045 is a standard being developed to define the eco-efficiency methodology. It is yet to be fully established as it is still under development. (International Organization for Standardization 2011.) However, it is so far in the development process that it can be seen to guide the eco-efficiency sector in the future with a shape almost or fully identical to its current form. ISO 14045 defines the formula for obtaining eco-efficiency ratios as follows.

$$Eco\ efficiency = \frac{Economic\ value\ added}{Environmental\ impact}$$

As can be noted, the ISO 14045 definition of eco-efficiency is identical to the one used by companies and researchers worldwide already. In essence an eco-efficiency evaluation conducted the ISO way adds a financial aspect to the Life Cycle Assessment. It uses the above mentioned formula of dividing the economic value added by the environmental impact (result of the LCA). (International Organization for Standardization 2011.)

While the magnitude of an ISO 14045 based eco-efficiency evaluation is clearly beyond the of scale this thesis, the standard helps to solidify the eco-efficiency formula and encourages adopting it as one key tool in a company's environmental toolbox.

Eco-efficiency calculations are not however always a straightforward deal. Based on the formula, one way of calculating eco-efficiency is to divide sales revenues with environmental impacts (Kharel and Charmondusit 2007). While this does provide a strong linkage between the economic and environmental aspects, the result can become distorted by the changes of the selling price. For example, if prices go up, they might diminish the negative environmental development, or in the worst case hide it completely.

The values used for calculating the eco-efficiency ratio must therefore be carefully selected. Actual environmental performance must be reported; it should not become overly distorted by fluctuations in the markets. It becomes clear that this tool is only to be used with great meticulousness.

Another feature to be taken into account with the eco-efficiency ratio is that because it factually is a ratio, it is only useful when comparing the eco-efficiencies of two or more products or investment, or when determining the development of a process over time. A single standalone eco-efficiency figure does not provide any real substance without a reference point from at least one other eco-efficiency ratio.

Eco-efficiency provides an interesting method to be incorporated in the result of the primary goal of the thesis, which is the created eco-performance measuring tool. If the numerator on the formula contains the number of stretch wrapping machines produced during a year and the denominator measurable environmental impacts, the principle of eco-efficiency is being implemented: eco-efficiency can be improved by producing more machines with current level of environmental impacts, or by lowering the environmental effect of the current production amounts. Obviously achieving both will further work for improving the result.

Eco-efficiency is also used when contemplating between different solutions (investments) for improving Haloila´s environmental performance in the secondary goal of the thesis. Optimally it will help to add a new dimension to evaluating different investment options.

Eco-efficiency Framework

After the principles of eco-efficiency are laid, it must be decided where to implement the actions. The framework for eco-efficiency considerations introduced by Penttinen (2010) in his doctoral thesis provides practical guidance in this matter. The framework is presented in Figure 2. It is a comprehensive list of what to take into account when working to improve a product´s eco-efficiency during its lifecycle, including the production stage, the subject of this thesis.

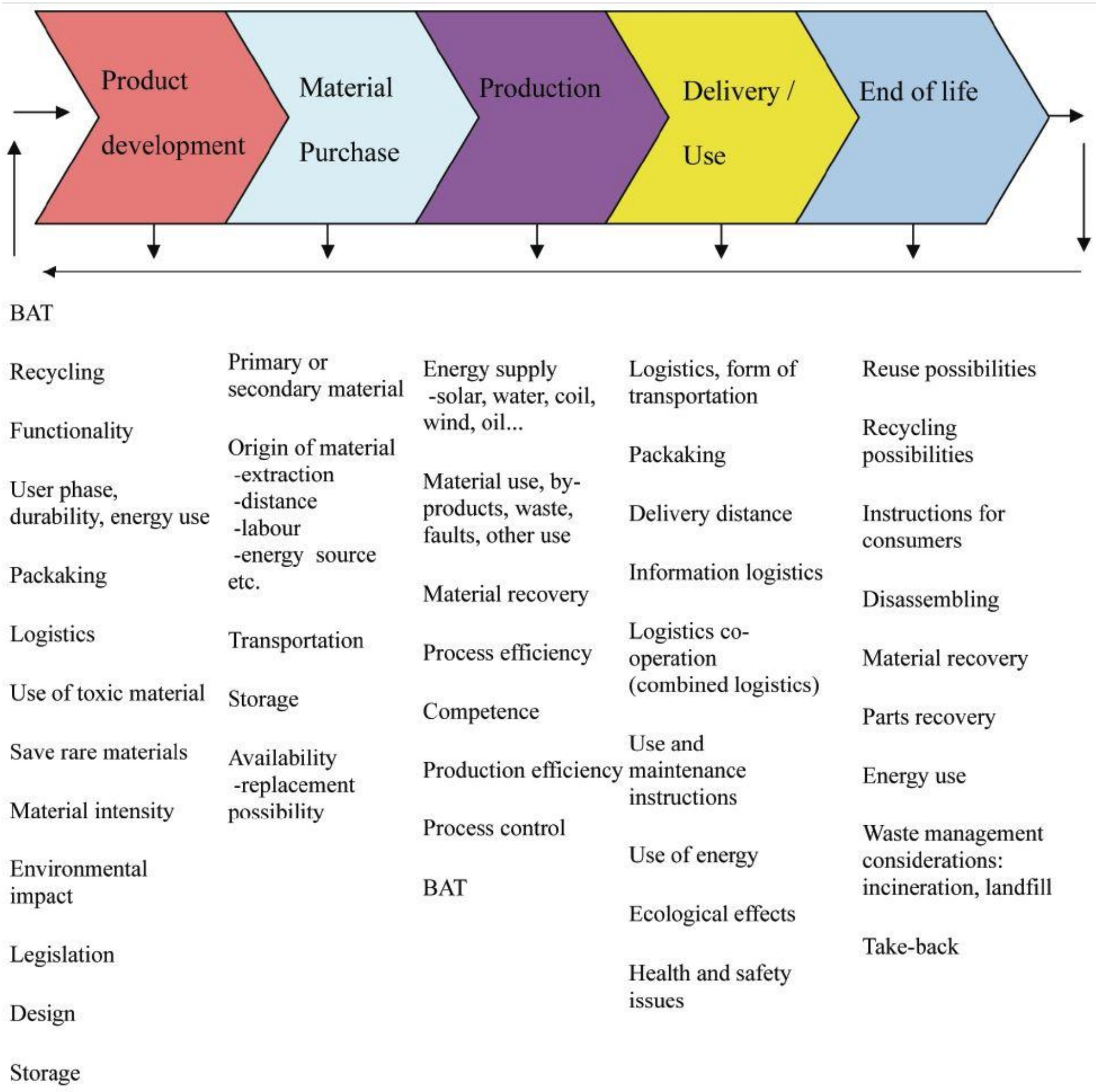

Figure 2. Framework of eco-efficiency considerations in different life cycle stages in SMEs (Penttinen 2010).

Some of the environmental impact categories at the production stage of the framework, mainly in the areas of energy, materials and waste, can be relatively easily measured and monitored at Haloila and are used to guide the formulating of environmental impact categories presented later in this thesis. Furthermore, the similarity of the eco-efficiency consideration areas of the framework with the ones presented in the theory part of the thesis help to further strengthen the validity of the environmental impact categories to be chosen.

3.4 Carbon Footprint

A system´s carbon footprint consists of greenhouse gases (GHG) emitted by the system (for instance a product) through all of its life cycle stages: from raw material acquisition, production, distribution, use, to disposal or recycling (Mattinen and Nissinen 2011).

All greenhouse gases have an individual Global Warming Potential (GWP) value. A GWP is an indicator that reflects GHG´s effect on climate change in a pre-defined time period, typically 100 years (expressed GWP100). (Mattinen and Nissinen 2011.)

The three most common GHGs are carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N2O). GWPs are given in carbon dioxide equivalents (CO_2e): in CO_2e based results reporting, all GHGs have their climate changing capacities converted to that of carbon dioxide. The GWP for CO_2 is thus 1, whereas for CH_4 it is 25 and for N_2O it is 298, making it almost three hundred times more harmful to the environment when compared to carbon dioxide. (Mattinen and Nissinen 2011.)

A carbon footprint for a system is calculated by multiplying the emission amounts of the greenhouse gases by their respective global warming potential value. The result of the calculations is a system specific carbon footprint. It is a single numerical value (for example kg CO_2e / system) that expresses the product´s life cycle effect on global warming in the terms of greenhouses gases converted to carbon dioxide emissions. (Mattinen and Nissinen 2011.)

In the United Kingdom, for example, the total impact on the climate is divided as follows: carbon dioxide 86%, methane 7% and nitrous oxide 6%. The remaining one percent is the effect of refrigerant gases. (Berners-Lee and Clark 2010.) Another source gives the non-CO_2 GHGs one third of the total CO_2e impact on global warming, while ⅔ is the effect of carbon dioxide (Meinshausen et al 2009).

More than 100 countries have agreed to global warming limit of 2 °C compared to pre-industrial temperatures. The probability of exceeding this goal rises in direct relation to growth of CO_2 emissions, as Figure 3 shows. (Meinshausen et al 2009).

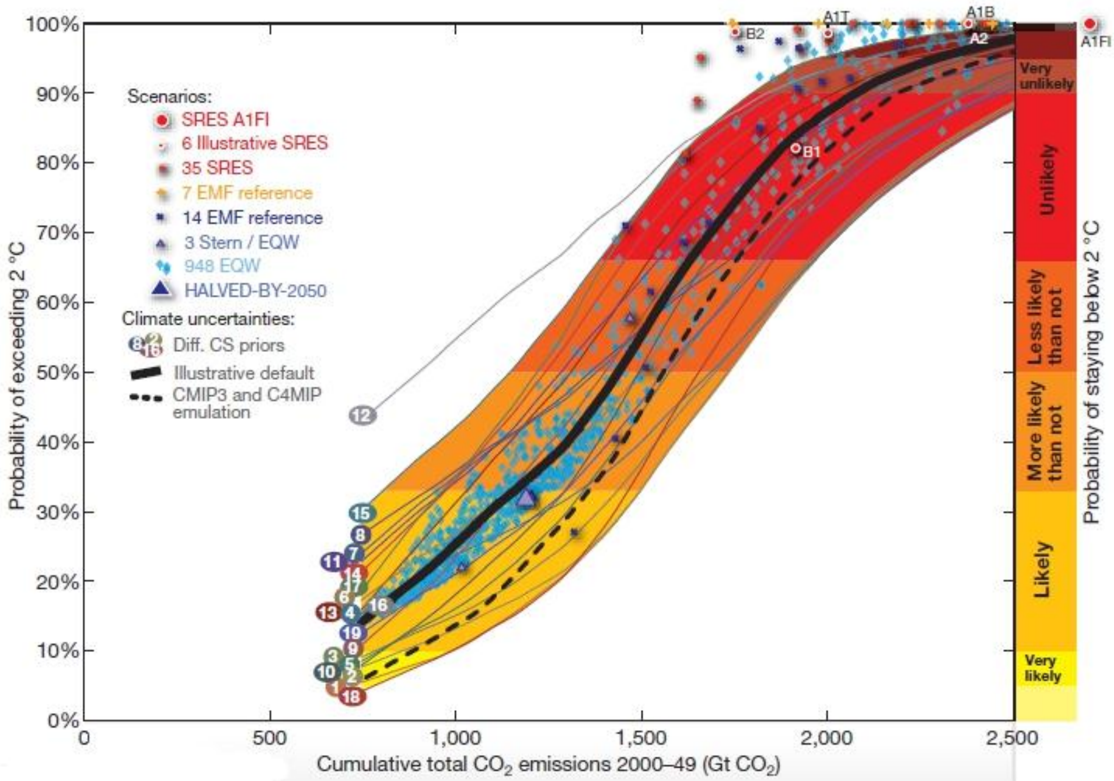

Figure 3. The probability of exceeding a 2 °C global warming versus cumulative CO_2 emissions in the first half of the twenty-first century (Meinshausen et al 2009).

Figure 3 shows the calculated effects of multiple scenarios on the global warming restraining goal during the years 2000-2049. While different scenarios lead to results of varying level of impact the trend is clear: release of CO_2 gases results in man-made climate change, or in other words, global warming (Wirtenberg et al 2008; Berners-Lee and Clark 2010).

Taking only CO_2 emissions into account and leaving CH4 and N2O out when determining a systems' carbon footprint is a valid option. This is suggested by Figure 3 and is often the chosen method (Heliö et al 2005). The large effect of CO_2 on the climate change compared to CO_2e based gases also indicates that this is an acceptable compromise. A carbon footprint based solely on CO_2 offers a tool for presenting the environmental effects an individual target, such as a building, has during a certain time period through certain fairly easily monitored functions.

For this thesis a carbon footprint consisting of CO_2 emissions will provide a basis for displaying the yearly carbon footprint of energy usage at the Haloila factory.

3.5 Polygon Model

One way to monitor the evolution of environmental performance in a company is by using a polygon model. A polygon model is a graphical tool that shows how the company has performed in its environmental performance categories during a year. Development is measured against a certain point in time, a baseline, for example the previous or a fixed year.

A similar tool named Eco-compass also exists. An eco-compass has the same polygonal form and it functions much in the same way as the polygon model. (Penttinen 2010.)

In this example from ArcelorMittal´s plant at Gent, Belgium, shown in Figure 4, the polygon consists of six corners, i.e. six measured environmental performance categories. The baseline in this particular case is the performance level of the year 1995 (in some categories 1998, due to lack of earlier measurement results). (Van Caneghem et al 2010**.**)

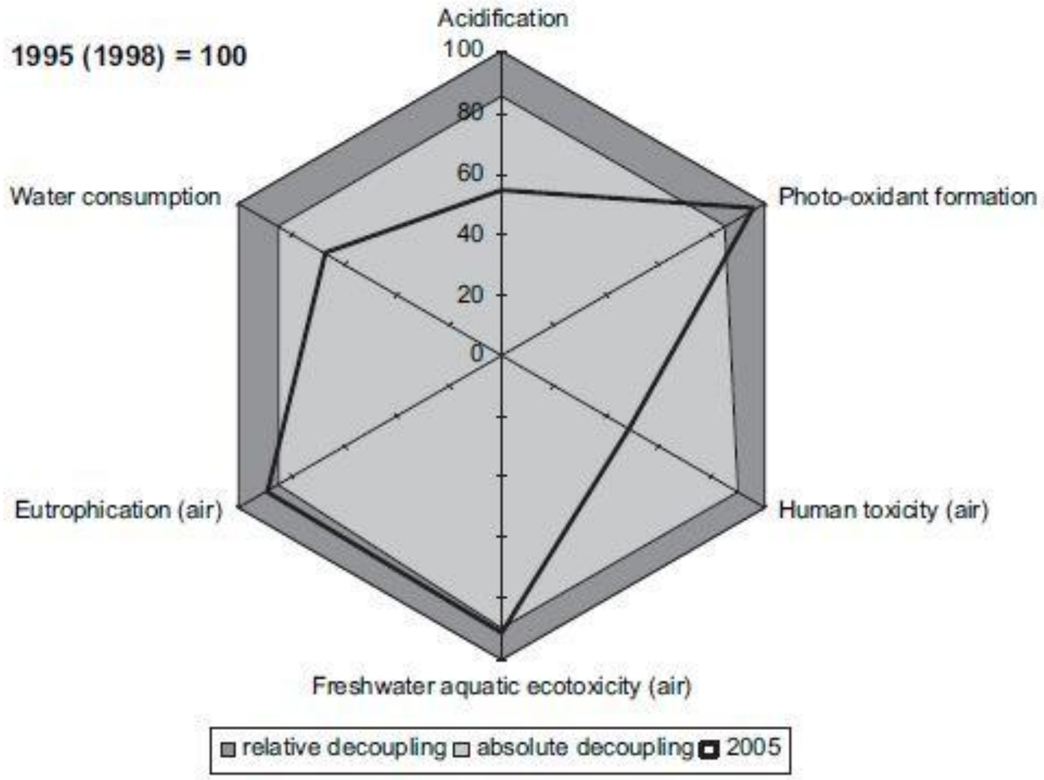

Figure 4. Eco-efficiency and decoupling of environmental impact and production by ArcelorMittal Gent (Van Caneghem et al 2010).

Even though the categories are somewhat different from the ones to be presented in this thesis, the basic principle applies. For each environmental performance category assigned to a corner (in Haloila´s case yearly environmental impact/produced machine, to be defined later on in this thesis) a value of 100 is given. This represents the level of performance at the baseline year.

Each year the new indicator results are calculated (in this example in the year 2005) and compared to the results of the starting point (1995/1998). The closer to the center of the polygon a particular corner value is, the better the development in that category. Individual results are joined together by a set of lines. Thus the formed shape gives an easily perceived impression on environmental performance trends during the examined time period.

Furthermore, this polygon model introduces the concept of *decoupling*. Decoupling means that the environmental impacts in a category decrease despite growing production or increase less than the production amount grew (Van Caneghem et al 2010). In other words environmental impacts do not build up in the same rate as the production amounts: the two are hence decoupled. From an environmental performance perspective, this is obviously a good thing. The word *de-linking* is also used to describe this very same phenomenon (Penttinen 2010).

Each environmental impact category is compared to the base value of 100 in both environmental effects and production amounts. If the new indicator value is between 85 and 100 it means that the environmental impact increased, but less than the production grew. Decoupling is then relative, it is not totally irrefutable. This is presented as a dark grey area in Figure 4. (Van Caneghem et al 2010**.**)

The light grey area (< 85) means that the impact of the indicator theme decreased, despite the growth of production amounts. The decoupling between the environmental impact area and the production is therefore absolute. (Van Caneghem et al 2010**.**) This indicates a very good environmental performance trend in these sectors.

The method suggested by this model can be seen as a solid application of eco-efficiency, as it takes into account the environmental aspect as well as the business aspect. The polygon model could provide a good visual tool to Haloila for monitoring effects of the work towards decreasing the environmental impact of its factory. The polygon model also visualizes the level of correlation between yearly production amounts and environmental impacts of the factory.

4 PACKAGING INDUSTRY ECO TRENDS

This section of the thesis provides a glimpse into the environmental trends arising from Haloila´s branch of business, the packaging industry. By obtaining an industry specific outlook on the matter, further assurance on the right direction for this thesis is gained.

The role of packaging is primarily to protect and promote the product, to enable convenient transportation of the product and to support efficient handling of the product throughout the supply chain (The Consumer Goods Forum 2011a). This applies to all stages of packaging, including transport packaging, also known as tertiary packaging, the field of activity for Haloila. This stage is pictured in the far right on Figure 5.

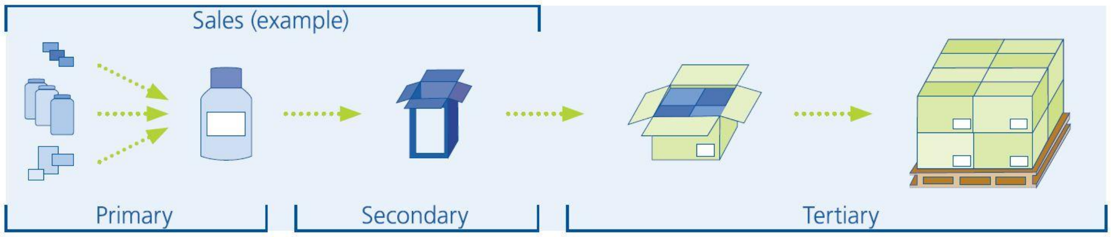

Figure 5. Packaging types (The Consumer Goods Forum 2011b).

As the final link in the packaging chain, Haloila´s products have to protect the results of the previous packaging stages. Because of this close connection within the packaging types, all three phases must meet the same criteria, including the field of environmental sustainability.

A concrete example of the growing role of sustainability in the world of packaging is the Global Protocol on Packaging Sustainability 2.0, orchestrated by the Consumer Goods Forum, a global network serving shopper and consumer needs. Global Protocol on Packaging Sustainability (GPPS) 2.0 is the result of a Global Packaging Project, which was initiated after a proposal made to the Global CEO Forum in 2008. (The Consumer Goods Forum 2011a).

The Global Packaging Project indicated a first step in the consumer goods industry´s mission to create a common language on all matters of sustainability in their line of business. Because of the enormity of the task ahead, a single focus area was identified to get the work started. This area was chosen to be packaging. (The Consumer Goods Forum 2011a).

GPPS takes into account the whole packaging system and it covers the complete packaging life cycle. It offers a common approach to sustainable packaging for all members of the packaging supply chain, clearly defining the used terminology and addressing the need to establish uniform goals and measuring systems. (The Consumer Goods Forum 2011a)

Approximately half of the machines manufactured by Haloila are sold to clients operating in the consumer goods sector (Vanhanen, J. 7.5.2012)). The Global Protocol on Packaging Sustainability 2.0 therefore provides a good indication on the status and future trends of the sustainability issues in one of Haloila´s most important business branches.

The next three subheadings present the main areas of the GPPS. Information gathered from them is used to guide the formulation of the strategies presented in the later parts of the thesis and to give a specific picture of the environmental demands arising from the global packaging network.

4.1 Environmental Attributes

GPPS offers a list of environmental attributes to guide trading partners in the packaging industry (The Consumer Goods Forum 2011a). These are topics that might come up for instance in business discussions between a packaging solution seller and a potential customer who emphasizes environmental issues in their purchases.

The list consists of the following topics:

- Packaging Weight and Optimization
- Assessment and Minimization of Substances Hazardous to the Environment
- Packaging to Product Weight Ratio
- Production Sites Located in Areas with Conditions of Water Stress or Scarcity
- Material Waste
- Packaging Reuse Rate
- Recycled Content
- Packaging Recovery Rate
- Renewable Content
- Cube Utilization
- Chain of Custody (The Consumer Goods Forum 2011a.)

As one of the goals of GPPS is to create a common language for all facets of packaging, the listed attributes will have to be met by Haloila products as well as those of any other operator in this field of commerce.

While the implementation of some of the attributes is a task to be considered, it is not in the to-do list of this thesis, but more a part of the designing process of the wrapping machines. The list does however offer a broadening look into the business specific eco-trends for the packaging sector and helps to validate the solutions presented later in this study.

4.2 Life Cycle Indicators

GPPS also presents a slate of life cycle indicators with the same intentions as the environmental attributes: to standardize the packaging business in the field of environmental responsibility.

The GPPS life cycle indicators are as follows:

- Cumulative Energy Demand
- Land Use

- Fresh Water Consumption
- Global Warming Potential
- Photochemical ozone creation potential (POCP)
- Ozone Depletion
- Acidification Potential
- Toxicity, Cancer
- Aquatic Eutrophication
- Toxicity, Non-Cancer
- Freshwater Ecotoxicity Potential
- Particulate Respiratory Effects
- Non-renewable Resource Depletion
- Ionizing Radiation (Human) (The Consumer Goods Forum 2011a)

The rather exhaustive listing accomplishes two things. Firstly, it helps to guide the future eco-efforts of Haloila in the directions specifically set for its industry area. This can well be used as a check-list when diagnosing the environmental performance of stretch wrapping machines.

Secondly and, for the sake of this thesis, more importantly, GPPS´s life cycle indicators help to further select and justify the environmental impact categories presented later in this study by showing that while business specific points of environmental interest do exist, the core of eco-thinking is quite universal.

4.3 Over Packaging

Global Protocol on Packaging Sustainability 2.0 displays a principle on the usage amounts of packaging materials in the consumer goods sector. According to it, it is more environmentally friendly to use excessive packaging guaranteeing adequate protection than it is to cause product losses by inadequate packaging (The Consumer Goods Forum 2011a).

The primary goal is to reach a point of optimum packaging, labeled as the Optimum Pack Design in Figure 6. (The Consumer Goods Forum 2011a).

Figure 6. Optimum packaging (The Consumer Goods Forum 2011a).

The protocol approaches the environmental performance of consumer goods packaging with a life cycle approach. Thus, the environmental impacts of potential product losses due to too little packaging outweigh those of too much packaging. Environmental impacts due to the manufacturing of lost merchandise have already occurred, whether or not the goods end up to the use of the end client.

An optimum pack design in the tertiary stage is achieved with well-designed packaging (The Consumer Goods Forum 2011a). This is best achieved with customer and pallet specific solutions, a core feature of Haloila´s Octopus machines.

What all of this means for Haloila is that the customer specific optimization of the Octopus machines for each different pallet type is a key environmental performance aspect. While this feature is created in the production phase of the machines, its effects come into action at the use phase of the machines life cycle. For that reason it will not be further evaluated in this study. Nonetheless, the writer of the thesis wants to underline it as one concrete environmental feature of Haloila´s Octopus products already in place that clearly works for the benefit of both the customer and the environment.

5 ENVIRONMENT AND HALOILA

Next the present state of environmental strategies in Haloila is examined. Also a brief look into the environmental status of Haloila´s closest competitors is provided.

Environmental responsibility is not achieved overnight. It is a manifestation of a working culture reaching every level of the company´s operations. A truly effective environmental policy infiltrates all levels of a company.

A situation where the company actively produces eco-innovations through its motivated employees can be seen as one example of a truly high-performing ecologically aware company, where environmental policies have led to not only obedience of rules and regulations but active collaboration from employees at all levels.

One way of describing the process of adapting environmental issues in to a company working culture is with a pyramid model presented by Wirtenberg et al (2008). The model is the result of a study on nine of the world´s most sustainable companies. It identifies seven core qualities associated with successful sustainability strategies.

The seven qualities are built into a four level pyramid, shown in Figure 7. In it the level of sustainable operations refines from bottom to top. Success in all sectors leads to so-called triple bottom line (economic, ecological, and social) results, the attainment of the peak of the pyramid. (Wirtenberg et al 2008.)

While this thesis only involves the ecological aspect, the pyramid model nevertheless offers a practical observational tool to be used, for the three corporate sustainability areas are that closely knit together.

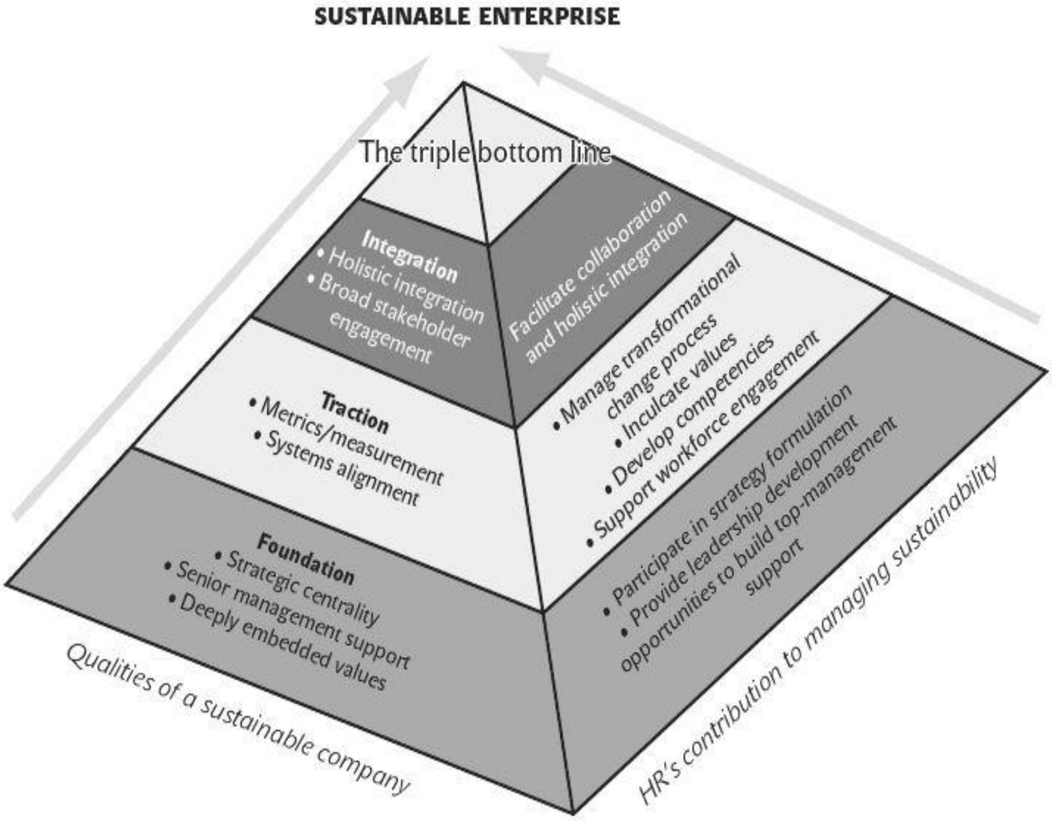

Figure 7. The Sustainability Pyramid: qualities associated with highly successful sustainability strategies (Wirtenberg et al 2008).

The *Foundation* level is where the companies´ deep held values considering sustainability are: top management´s visible support for sustainability and its placement in the company´s corporate strategy (Wirtenberg et al 2008).

The second level of the pyramid is the *Traction* level. In this level, engagement of the employees must happen as well as the development and use of sustainability metrics (Wirtenberg et al 2008).

The highest level of the pyramid, the *Integration* level, is where broad stakeholder engagement and holistic integration of sustainability into the company´s every part takes place. Reaching this cross-boundary, multi-stakeholder, interactive pinnacle has proven to be a demanding task for even the world´s most sustainability-wise highly rated companies. (Wirtenberg et al

2008.) An integration pinnacle is something that some of Haloila´s major clients can be seen to strive for, thus affecting the demands posed towards Haloila as a machine supplier.

At the moment Haloila has a solid foundation close to being ready. It has conducted studies on environmental issues before (Nurminen 2009) and discussions on implementing environmental values on the company's mission and vision statements have taken place. Clearly, sustainable business is something that has, if not yet strategic centrality, most surely the support of Haloila´s senior management.

This study is a step for Haloila into the Traction level. By creating environmental metrics and a measurement system to be used at the factory, the company continues its work towards being an active environmentally sustainable operator.

A company working at the integration level on environmental issues can be described with Figure 8 (Arnold and Hockerts 2011). It is a presentation of a company where eco-issues are fully integrated into the company to that extent that a management system of eco-innovations is needed.

Figure 8. Eco-innovation process in a company (Arnold and Hockerts 2011).

The eco-innovation process presented by Figure 8 is created based on a study done on Royal Philips Electronics, a Dutch company also known simply as Philips. Philips can be seen as having achieved the pinnacle of the sustainability pyramid, as environmental issues have a role across the company. The study focused on Philips´s Green Flagging Program, a system that Philips uses to manage its environment related innovations (Arnold and Hockerts 2011).

While this is an example of an extremely high-performing corporation ecologically-wise, it offers an idea of what it actually takes to achieve the eco-advantage.

According to the study, the workload on a company producing and thus managing eco-innovations is significant. While the integration of sustainability into the product design process may be seen of being achieved with moderate effort, recurring eco- and sustainability programs, intra-organizational education programs, or firm internal platforms and networks on eco-innovations are not features already place in many companies. Nor are they something that can be created without a significant amount of resources.

If this is the result of obtaining the highest level on the sustainability pyramid, it raises the question whether it always worth it. Strictly financially speaking, if a company the size of Haloila wishes to obtain an eco-advantage over its competitors, whose environmental activity is analyzed next, it also has to decide how big of an amount of resources it is willing to re-route or add for this purpose.

It must be so that the amount of money gained from improved environmental performance should be greater than what is needed to achieve it. Perhaps the peak of the pyramid is not always the desired state, rather than a level where the demands of ecological actions do not outweigh the positive business results emerging from them.

6 ENVIRONMENT AND HALOILA'S COMPETITORS

This section provides a brief look into the publicized environmental values of Haloila´s closest rival companies. The basic assumption is that should a company be environmentally active, it will promote this on its internet homepage. All the data is thus collected from companies' respective websites. This makes this a somewhat cursory review on the topic, especially considering that the author was unable to find annual reports or any other kind of official or unofficial reports on the companies. For this reason the companies' environmental strategies are neither analyzed with the previously presented pyramid model nor overly examined in any other way.

Haloila faces competition from the following companies: Bema (based in Italy), Ocme (Italy), Robopac (San Marino), Strema (Germany), Tosa Group (Italy) and Wulftec (Canada) (Pietilä 2011). English language versions of the webpages were studied on all of the companies´ cases, except Strema, whose English language website was not functioning.

Bema

Bema´s homepage is not in any way flooded with eco-values. There is however one occasion of clear environmental value based marketing. It is on the section that covers the attributes of their Silkworm stretch wrapping machine. (Bema 2012.)

Silkworm has reportedly increased its pre-stretching to 400 %. This combined with 1000 mm film reels is said to gain 20 % to 40 % savings in the film quantity used wrapping palletized products. (Bema 2012.) For this the Silkworm machine is given an environmental emblem on this section of the company's internet page.

Picture 4. Silkworm, respecting the environment (Bema 2012).

This piece of eco-information, along with the logo shown in Picture 4, is not at the forefront of the webpages. It can be found under the Silkworm product line´s features section after some searching. Ecological values are not something Bema seems to emphasize.

Ocme

Ocme has an environmental (and social) responsibility program according to its webpages. On the home page an eco-banner seen in Picture 5 is placed in the clearly visible midsection of the page layout. (Ocme 2012.)

Picture 5. Ocme World Care banner (Ocme 2012).

Upon further review it becomes clear that Ocme´s WorldCare campaign consists solely of recycling. The original text is dated to 2003, the last update has taken place in January 2009. (Ocme 2012.) On the basis of this, one could argue that WorldCare is not the most active part of Ocme´s managerial tool box.

Nevertheless, in its WorldCare program Ocme showcases its commitment to sort solid urban waste and tries to encourage its employees to also look after the environment along these same lines (Ocme 2012).

Ocme also highlights environmental values in some of their product lines, such as the Vega shrink wrapping machines. Features such as “Green” engineering and “Energy saving kits” are brought up immediately after the most basic technical specifications of the machines. (Ocme 2012.)

Ocme also lists three more actions to improve their environmental performance. These are listed under the social responsibility section of their homepage. The first two actions involve Ocme’s car fleet. Firstly, some of the cars are powered with natural gas and secondly, Project 2010 replaces all the vehicles with ones that have a CO_2 emission lower than 150 g/km. The third action involves Ocme shrink wrap machines, whose energy consumption is subjected to a 30 % reduction. (Ocme 2012.)

It remains unclear whether these actions have already been undertaken or not, for no further reporting on them is present. Be it as it may, it seems that Ocme has an environmental strategy and that it is promoting eco-issues on a company and product level. The actual implementation of their plans remains questionable, mostly due to lack of any sort of factual measured data.

Robopac, Strema and Tosa Group

Neither Robopac, Strema nor Tosa Group offers any environmental information on their Internet pages (Robopac 2012; Strema Machinenbau Gmbh 2012; Tosa Group 2012).

Wulftec

Wulftec´s home page has, at the very bottom, an environmental banner. The banner is presented in Picture 6. It is the only path to eco-issues on the Wulftec´s Internet pages. Environmental information is not present for example at neither the company information area nor the product features section. (Wulftec 2012.)

Picture 6. Wulftec, we are green banner (Wulftec 2012).

The “We are green” section of Wulftec´s home page lists five individual points that form the company’s green strategy: reduced energy usage by throughput anticipation, reduced film waste by optimized resolution, reduced general waste by better product protection for handling and transport, variable frequency drives and reduced greenhouse gas emissions due to the possibility of using manual pallet jacks on the semi-automatic turntable machines (Wulftec 2012). All five parts contribute to energy savings for the user of Wulftec wrapping machines, i.e. the customer of Wulftec, at use phase of the machinery´s life cycle.

Wulftec´s environmental strategy statements give a somewhat crude impression of the true quality of their eco-activity. It is more in the lines of a list of already existing product features that can be thought of having a green quality, instead of a program where active work on environmental issues takes place. On the other hand, all the above-mentioned points are valid and as such can be said to have a positive effect on the environment.

7 CREATING MEASURING TOOLS

This chapter of the thesis forms the first half of the results achieved by the study. It focuses on creating environmental performance measuring tools for the use of Haloila. The environmental impact categories to be presented are chosen based on the findings in the theory section.

In the simplest form, environmental impacts consist of liquid effluents, atmospheric emissions and solid wastes (Helminen 2000). The environmental impact categories introduced in this thesis all commit to one or more of these three categories.

The majority of the information put into categories comes from the already existing reports available to Haloila through its EHS (Environment, Health and Safety) reporting system. The materials section is an exception to this. At the moment Haloila´s systems do not produce information on the weight of purchased materials. The materials section is nonetheless included in this thesis for if implemented, it would offer a solid base for the realization of “more-from-less” thinking.

Environmental impacts are greatly affected by the production amount (Bayer 2010). For this reason each environmental impact category´s result is divided by the production amount of machines. The result will be an eco-efficiency figure that indicates environmental performance of the factory measured against the number of machines manufactured that year.

Environmental impact categories chosen to be used for monitoring the environmental performance of the Haloila factory in Masku are:

- Energy (electricity and heating), yearly consumption
- Materials, yearly consumption
- Water, yearly consumption
- Waste, yearly generation

The chosen categories comply with the current trends in the different environmental responsibility fields presented earlier in this thesis. Together they offer a platform for measuring and continuously improving the factory´s eco-performance.

Yearly eco-efficiency calculations are to be carried out in the five environmental impact categories. Obtained eco-efficiency ratios are used to form an environmental performance monitoring tool for Haloila. In the case of heating energy, further financial calculations are performed to be used in the second half of the results section of this thesis covering the targets for environmental performance improving.

7.1 Energy Usage at Haloila

Energy usage consists of the energy brought (bought) into the factory (Heliö et al 2005). Possible forms of energy consumed in industrial buildings are: electricity, district heat, fossil fuels, other fuel based energy and non-fuel based energy (Erkkoa et al 2003). In the case of Haloila, energy usage is formed from electricity used at the factory and the heating oil used in the factory’s boiler.

Electricity usage covers all the electricity used by the factory. The usage of heating oil indicates the amount of direct energy used to heat the factory. Information on both usages is gathered from the company’s already existing reports.

Both forms of addressed energy consumption lead to CO_2 emissions (Motiva 2010). Only CO_2 emissions are taken into account, whereas CO_2 equivalent releases are not studied. The result will be a carbon footprint that will provide a good base for keeping track of the factory´s environmental performance in the energy sector.

7.1.1 Electricity Usage

Production of electricity creates CO_2 emissions on a wide scale: from the 0 grams of CO_2 per produced kilowatt hour of wind power (Teknologiateollisuus Ry 2012) to 341 and 381 grams of coal and peat power respectively (Motiva 2010). Average CO_2 emissions per one kWh of electricity sold in Finland is 200 grams (Motiva 2004; Motiva 2010)

The actual CO_2/kWh figure of an individual electricity user depends on the electricity production method(s) used by the company the power is purchased from (Motiva 2010). The current electricity supplier for Haloila is Turku Energia. Their CO_2 g/kWh number is 284 (Turku Energia 2012).

Electricity usage at Haloila in 2011 was 539,367 kilowatt hours (Haloila 2011a). When this is multiplied by the CO_2 g/kWh number of electricity bought from Turku Energia, a sum of 153.2 CO_2 t (tons) is obtained. Total cost of the electricity consumed by the factory was 42,580 € (Haloila 2011a).

The eco-efficiency ratio of the factories´ electricity consumption is calculated by dividing the amount of produced machines with the environmental impact of the electricity consumed.

$$\frac{206\ units}{153.2\ CO2\ t} \approx 1.34$$

For comparison, when the yearly electricity usage at the factory is multiplied with the average Finnish electricity CO_2 figure of 200 CO_2 g/kWh, the theoretical carbon footprint of the yearly electricity usage amounts to 107.9 tons of CO_2.

To show how the average Finnish electricity CO_2 figure would improve the eco-efficiency ratio in this environmental impact category, a new eco-efficiency calculation is performed.

$$\frac{206\ units}{107.9\ CO2\ t} \approx 1.91$$

7.1.2 Heating and Cooling Usage

Haloila´s factory is currently heated with heating oil. Oil is used to heat water in a warm water tank. Heat energy from the heated water is distributed into office and production spaces through heaters mounted on walls and blowers in the production hall.

Oil consumption in the year 2011 was 97,049 liters (Haloila 2011a). The energy content of heating oil is 10.02 kWh/liter (Motiva 2010). The gross heating energy discharged from the oil used by Haloila was thereby 972 MWh.

Heating oil discharges 267 g of CO_2 for every kWh of output (Motiva 2004). The usage of heating oil in 2011 thus resulted in a carbon footprint of 260 CO_2 tons in 2011.

The eco-efficiency indicator for the heating of the factory is as follows.

$$\frac{206\ units}{260\ CO2\ t} \approx 0.79$$

For the sake of further comparative calculations in this thesis, the actual share of energy from the oil used to heat the factory is required. The oil is burned for heating energy in a Rauma Repola (model year 1987) boiler. The nominal power of the boiler is 0.51 MW. It is serviced once a year, but its efficiency coefficient is unknown. The average energy coefficient (EC) of an oil boiler is 0.85-0.93 (Motiva 2004; Motiva 2010).

If the EC is 0.85, the actual heating energy consumption of the factory in 2011 was 827 MWh. EC of 0.93 would indicate 904 MWh worth of heating energy used. The average of the two figures will be used for it should provide realistic enough results: 866 MWh represents the actual heating energy usage of the factory in 2011.

The price of heating oil used by Haloila in 2011 was 80,345 € (VAT 0%) (Haloila 2011a). This divided with the actual heating energy usage of 866 MWh results in the cost of 92.8 €/MWh.

The cooling of the factory (namely its office spaces) is handled by an air conditioning central unit. This unit is an electronic device and as such it draws its energy from the power network just as every other electric device on the factory premises. Its energy usage is not monitored separately and for that reason it cannot be further evaluated.

7.1.3 Carbon Footprint of the Factory

Energy use of buildings accounts for 40 % of the energy used in Finland (Heliö et al 2005). Thermal and electrical energy usages are the main components of a buildings environmental impact (Melchior 2012). The majority of this usage is generated at the use phase of a buildings life cycle (Heliö et al 2005).

With its yearly heating energy consumption of 866 MWh, Haloila´s Masku factory uses 50 % more heating energy than a typical large-scale Finnish high-rise (Energiateollisuus 2012). The factory´s electricity usage adds to this with a 540 MWh share.

A somewhat advisory carbon footprint for the factory can be obtained by combining these two yearly CO_2 emissions. This method, while not completely in line with the strictest definitions of a CO_2e-based carbon footprint evaluation presented earlier in this thesis, does provide a number that has a direct effect on the environment and is a good observational tool.

CO_2 emissions from these two sources added together form the following carbon footprint:

$$153 \text{ CO2 t} + 260 \text{ CO2 t} = 413 \text{ CO2 tons}$$

413 tons of CO_2 is a figure that to a good extent demonstrates the energy performance of the factory in 2011. As such, it also offers a good landmark to measure future performance against.

7.2 Material Usage at Haloila

This section was intended to include statistics on the material usage at the factory. Ideally everything from disposable coffee mugs used by employees during coffee breaks to machined metal pieces used for the frames of Octopuses would be included.

The idea behind this approach is that any purchased material is thought to having environmental impacts in its previous life cycle stages. A full ecological impact assessment of individual items would be a monstrous task, whereas this simplified method would require no extra research or calculation work.

Every piece of material entering the factory would be included. Environmental impact of purchases would be indicated solely by their respective masses. To accomplish this, the purchasing system would have to start tracking each incoming shipment´s gross weight.

Such a feature is not yet present at Haloila. Nor is a system that would track, for example, the weight of materials used as parts for the machines. For this reason, the data input for this environmental impact category is at the moment non-existent. Therefore it cannot be further developed at this point in time.

It can only be suggested to be added as another tool to Haloila´s already well performing automatic monitoring system on environmental issues. The suggested method would offer a way to track the actualization of “more-from-less” thinking at the factory.

Dividing the amount of machines produced in a year with the total mass of incoming articles during that same time would result in a yearly monitored eco-efficiency ratio. This ratio would provide a solid indication on the material efficiency of the factory in a simple but effective manner.

7.3 Water Usage and Wastewater Generation at Haloila

Water usage and wastewater generation are not separately recorded at Haloila. The municipality of Masku´s technical department bills Haloila on the basis of water consumption. This number is used to charge for wastewater generation as well. The two are hence considered to be identical in volume.

In 2011 water consumption was circa 400 m^3. The average price paid for water that year was 1.33 Euros/cubic meter (VAT 0 %). This amounts to 532 €. Wastewater generation was billed for the same volume based on the above-mentioned reason. Its average price was 1.77 €/m^3. This totals 708 €. (Haloila 2011a.)

The yearly cost of 1240 Euros is hardly a big monetary factor for a business of this size. Additionally, as the yearly freshwater usage of 400 m^3 is only roughly the yearly consumption of seven Finnish persons (155 liters/day/person) (Motiva 2011b.), Haloila´s operations seem in no way to have a large effect on the Finnish freshwater resources or the wastewater system.

Water consumption, especially freshwater consumption, alongside all sort of releases from the factory are such an integral part of the environmental responsibility field, that their inclusion in the environmental performance indicator categories is nevertheless favored, despite their relatively small amounts.

When the water consumption at Haloila in the year 2011 is combined with the factory's output in sold machines during that same time, the following result emerges as the eco-efficiency ratio for this sector.

$$\frac{206\ units}{400\ \mathrm{m3}} \approx 0.52$$

Wastewater generation obviously achieves the same index number, as the two use the same yearly volume value. Unless the wastewater generation is to be separately monitored, it is the opinion of the author of this thesis that monitoring the yearly water consumption is sufficient for this environmental impact category.

7.4 Waste and Recycling at Haloila

Waste can be seen as misplaced raw-material. Therefore it is important for a company to lose as small amount of materials from its economic system as possible. (Suomen itsenäisyyden juhlarahasto 2009**.**)

In practice totally solid waste free operations in an industrial environment are not possible. Environmentally and natural resource wise the best option is to generate as little waste as possible. Preventing waste is more beneficial for the environment than recycling or any other utilization of waste. (Vaittinen 2004.)

On a positive note, recycling leads to, among other things, reduced GHG emissions, conservation of limited natural resources and savings in energy consumption, all largely the result of keeping waste away from landfills and thus a lesser need to produce products from new, “virgin” materials (Wieman 2011.). However, recycling does consume energy in collecting, transporting and handling the recycled material. It is also a process in itself that generates waste. (Vaittinen 2004.)

In 2011 Haloila Masku factory generated 21.21 tons of waste (Haloila 2011a). This number includes the waste disposed by normal means and hazardous waste, which requires further processing. Non-hazardous waste management costs amounted to 9000 € in 2011. Hazardous waste management totaled 640 € worth of costs, making it a rather small sector.

Based on the above stated information and on the goal of providing as simple to use tools as possible, the environmental indicator on waste production takes into account all the waste generated at the Haloila factory. This covers all waste types, whether they end up as being burned for energy, recycled, in a landfill or further processed.

This way the only means to better performance in this area is to decrease the amount of waste produced, which is environmentally wise the best all-round solution. Another option would be to leave all the recycled material away from this piece of statistics.

When the yearly total waste generation number is converted to an eco-efficiency figure with the help of produced machines in that year the following result is obtained.

$$\frac{206\ units}{21.21\ waste\ tons} \approx 9.71$$

7.5 Eco-compass for Haloila

Eco-efficiency numbers obtained from the individual environmental impact categories are used to create a visual tool, an eco-compass for monitoring the factory´s environmental performance on a yearly basis.

De-coupling is taken into account more straightforwardly on this model than on the polygon model presented in the theory section. In it de-coupling had to be separately calculated and only index values lower than 85 were considered to be fully de-coupled.

In this eco-compass presented for Haloila the usage of eco-efficiency ratios means that the system has de-coupling monitoring already built into it. If the eco-efficiency ratio of a particular environmental impact category is greater in the year in question than at the base year level, this means that in this area environmental performance has improved despite the changes in production amounts; ecological effects are decoupled from production volumes.

The eco-compass uses index values formed from eco-efficiency ratios. Base year values are given an index number of 100. Index numbers for the year examined are created by comparing the reciprocals (1/x) of the two periods, *x* being the eco-efficiency ratio of the impact category at the year in question.

Here the index number calculation is done as an example in the environmental impact category of waste generation. The year studied is 2012, where production and waste amounts are arbitrarily designated as real values are obviously not yet available. The amount of production shall be 240 units, and the amount of generated waste 22.0 tons. This would generate the following eco-efficiency.

$$\frac{240\ units}{22.0\ waste\ tons} \approx 10.91$$

The first step in determining the new 2012 value for the eco-compass is to calculate the reciprocal for both years´ eco-efficiencies.

2011 (base year):

$$\frac{1}{9.71} = 0.103$$

2012:

$$\frac{1}{10.91} = 0.092$$

The second step is to calculate the index number for 2012, marked here by *y*.

$$\frac{0.103}{100} = \frac{0.092}{y} \rightarrow y = \frac{0.092 * 100}{0.103} = 89.3$$

The final step is to place this newly obtained index number for the year in question to the eco-compass. This is presented by a red line on Figure 9.

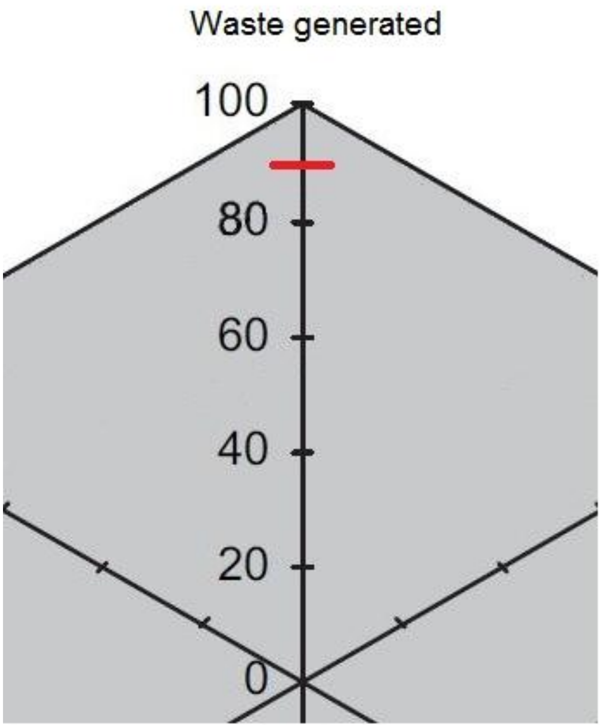

Figure 9. One corner example of an eco-compass for Haloila (modified from Van Caneghem et al 2010).

The same steps are taken for each of the impact categories. The resulting points on the graph are connected with lines in the same fashion as was done in the theory section. The result will be an eco-compass where yearly development can be easily monitored in all of the chosen environmental performance sectors.

8 FINDING TARGETS FOR IMPROVEMENT

This section firstly focuses on combining the lessons learned from the theory section of the thesis with some practical ideas on how Haloila can improve their environmental performance at the production phase, more specifically at the factory level. The area chosen as the field to be developed is the heating technology used to heat the factory.

Heating amounted to 63 % of the factory's energy consumption based carbon footprint in 2011. Also, of the five suggested environmental performance monitoring categories, its' yearly costs were clearly the highest (materials excluded, as information on them is not yet available). This makes it an extremely interesting area to optimize, in both ecological and financial terms. All the presented investment options are measured against the current oil based heating system.

Secondly, a few ideas are presented on how to actually start working towards an even more environmentally conscious Haloila at a business level. These address the issue of how to actually incorporate the ideas presented in this thesis to Haloila´s everyday actions.

8.1 Heating Investment Eco-efficiency Analysis

The main objective of the following phases is to give the company an idea on how they can enhance their factory´s ecological efficiency with the help of possibly only one investment and more importantly, how to apply an eco-efficiency mindset brought forward by this thesis to the investment decision making processes.

As stated earlier, environmental strategies in general exist to create shareholder value. Based on this precept it is decided that only investment options that financially outperform the current heating solution are analyzed. All of the three substitutive heating solutions to be presented meet this criterion as their yearly running costs are lower than those of the current heating oil system.

Out of the many ways to determine an investment's financial viability, the procedure chosen to be used in this case is the Net Present Value (NPV) method.

In a Net Present Value calculation all expected in- and outflows of money from an investment are discounted into their respective values at the present point in time, that is to say the time when the investment is made. In the following formula RPV stands for the present value of revenues and CPV for the present value of costs. (Joronen 2010.)

$$RPV - CPV = NPV$$

As the formula demonstrates, if the present value of the money generated by the investment is greater than the costs stemming from it, the result is a positive number. This indicates a profitable investment. (Joronen 2010.)

A more specified formula is needed to actually perform NPV calculations. The following formula is used in this thesis (Joronen 2010).

$$NPV = ANR * a_{\frac{n}{\overline{i}}} + v^n * SV - PP$$

ANR is the projected annual net revenue of the investment, $a_{\frac{n}{\overline{i}}}$ is a cumulative present value factor over a time period of *n* years with a required rate of return of *i* percent, v^n is a present value factor if an investment is thought of having a scrap value (SV) at the end of its usage period and PP is the purchase price of the investment. (Joronen 2010.)

All the investment options to be presented are subjected to the same criteria: a 20 year life span, a required rate of return of 20 % due to uncertainties considering the future development of energy prices and the differences between them, and a scrap value of 0 Euros. Zero SV naturally removes this bit of the formula altogether.

Because of the limited resources for the writing of this thesis, actual purchase prices for the investments are not gathered or estimated. Rather the formula is used to calculate what the maximum cost of a particular investment would be based on its yearly money making ability and on the above-mentioned criteria. The applied formula is as follows.

$$ANR * a_{\overline{n}|i} - PP = Maximum\ cost\ of\ investment$$

The annual (net) revenue is calculated separately for every investment option. The $a_{\overline{n}|i}$ factor is the same in every instance. Value of $a_{\overline{n}|i}$ with the selected terms is 4.870 (Joronen 2010).

Three possible compensatory heating solutions (district, electrical and geothermal) for the current method of heating with oil are analyzed with the help of eco-efficiency.

8.1.1 District Heating

Finland is among the leading countries in district heating (DH) usage. DH covers half of the heating markets in Finland. In major Finnish cities over 90 % of the energy used to heat buildings and water is from district heating. District cooling is also possible and it has increased its popularity in the 21st century. (Teknologiateollisuus Ry 2012.)

District heating mainly uses natural gas, coal and peat for fuel. Renewable biofuels, such as woodchip, are compounded with non-renewable fuels for more environmentally friendly operation. Biofuels had an 18 % share of the DH fuels in 2010. (Teknologiateollisuus Ry 2012.)

Finland is a world leader in combined heat and electricity production. Efficiency coefficient of a co-production plant, where both heating energy and electricity is generated, can rise to over 90 %. Currently 71 % of DH comes from co-production sources. (Teknologiateollisuus Ry 2012.) When district heating comes from these types of origins, it is a highly ecologically potent option

Fuel compounds used and whether or not the energy comes from co-production sources greatly affect the overall environmental performance of district heating. For that reason, the eco-efficiency of heating (and possibly cooling) a building with DH must be analyzed individually in every case.

The energy efficiency ratio of district heating is 100 % (Motiva 2010), therefore all the purchased energy can be thought of being used for heating purposes. The price of district heating energy obtained from Turku Energia is 60.4 €/MWh (Energiateollisuus 2012). With the current 866 MWh/a need of heating, the energy costs of DH would be 52,306 € per year. Compared to those of heating oil (80,345 €), DH would yield a 28,039 € annual revenue.

Applying the aforementioned NPV formula a result is obtained regarding the maximum purchase price (PP) of DH with the selected investment criteria:

$$28{,}039€ * 4.870 \approx 137{,}000€$$

The result indicates that an investment in DH would be profitable if it were to cost less than 137,000 Euros. Without taking further of a stand on this figure, it should be stated that the joining fee of a client roughly the size of Haloila entering the Turku Energia district heating network is circa 27,000€ (VAT 0%) (Energiateollisuus 2012). This would leave 110,000 Euros for equipment and labor costs.

Turku Energia reports a 341 kgCO_2/MWh emission for district heat in year 2010 (Turku Energia 2012). The average figure of a Finnish co-production district heating supplier is 220 kgCO_2/MWh (Motiva 2004).

With the current eco-performance of DH from Turku Energia multiplied by an annual heating need of 866 MWh for the Haloila plant, the carbon footprint would be 295 tCO_2/a. The same calculation with the average emission from a co-production plant results in a yearly carbon footprint of 191 t CO_2.

Based on the eco-efficiency formula of dividing the financial value added with the environmental impacts, an eco-efficiency ratio can now be calculated for the district heating option. Financial value added is the yearly gross profit made from using this less expensive energy source compared to the current situation. Environmental impact is formed by the CO_2 emissions created per one MWh of heating energy used.

The eco-efficiency ratio for the currently available DH from Turku Energia is calculated next.

$$\frac{28{,}039\ €}{341\ \frac{kg\ CO2}{MWh}} \approx 82$$

Since Turku Energia has publicly stated its intentions to increase renewable and CO_2-free energy acquisition and production in the near future (Turku Energia 2012), and also for the sake of comparison, another calculation for the eco-efficiency of DH is performed. The financial figures are kept the same but the environmental impacts are lowered to the level of an average Finnish co-production plant.

$$\frac{28{,}039\ €}{220\ \frac{kg\ CO2}{MWh}} \approx 127$$

8.1.2 Electric Heating

Electric heating uses electricity directly for heating purposes. The current electricity supplier for Haloila is, as stated earlier, Turku Energia. The electricity network operator is Fortum. The total amount of money paid to these parties in 2011 was 42,579 Euros (VAT 0%) (Haloila 2011a). This sum divided by the 539,367 kWh electricity consumption for that year leads to a cost of 0.0789 €/kWh, or 78.9 €/MWh.

The energy efficiency ratio of electricity heating is 100 % (Motiva 2010). The current level of yearly heating demand (866 MWh) would equal a 68,327 € heating cost if the plant was heated by electricity.

Compared with the yearly costs of oil heating (80,345 €), this would lead to a 12,018 € annual revenue in favor of electricity heating. This allows for a NPV calculation to be executed in the same manner as was done with district heating.

$$12{,}018€ * 4.870 \approx 59{,}000€$$

The price of this investment can be, based on these calculations, less than half of that of district heating. Most likely this should not pose a significant problem, for this solution does not carry a joining fee and the technology used is fairly simple.

Eco-efficiency for this heating option can be calculated by dividing its yearly gross profit over the current heating solution with its environmental impact per used MWh (284 CO_2 kg/MWh). The same number can also be used to calculate this heating options yearly carbon footprint, resulting in 246 t CO_2.

$$\frac{12{,}018\ €}{284\ \frac{kg\ CO2}{MWh}} \approx 42$$

The same calculation with the more environmentally friendly figure of the average Finnish electricity provider (200 CO_2 kg/MWh) leads to a more positive eco-efficiency ratio and a smaller carbon footprint of 173 t CO_2.

$$\frac{12{,}018\ €}{200\ \frac{kg\ CO2}{MWh}} \approx 60$$

8.1.3 Geothermal Heating

Geothermal heating (GH) uses energy stored into the ground, crag or water from the suns heat. Electricity is used to harness this heat. GH is a fairly expensive investment. The bigger the heated building, the more likely GH will be a financially viable option. (Motiva 2011a.)

Typically, a yearly energy co-efficient for GH is 3: three units of heat are obtained by the usage of one unit of electricity. The co-efficiency ratio is affected by the heat distribution method of the heated building. The greater the surface area of the heating surface, the lower the temperature of the cycled water can be and the higher the efficiency. (Motiva 2011a.)

In the case of Haloila, where no large surface area floor heating is available, but instead, the heat is distributed through much smaller planes, the yearly efficiency ratio will likely be lower than three. It is estimated to be 2.5. Based on this figure and with the yearly heating need of 866 MWh, GH would require 346 MWh worth of electricity for its operations.

With the currently purchased electricity from Turku Energia, this would lead to a 98 ton CO_2 footprint. The price of 78.9 €/MWh would result in a yearly heating cost of 27,299 Euros. Compared to the current yearly cost of heating oil a 53,046 € profit would be achieved.

With the same criteria for this investment as with district and electric heating, the following result is obtained for the maximum cost of an investment in geothermal heating.

$$53{,}046€ * 4.870 \approx 258{,}000€$$

Based on the small sample size of information gathered via e-mail from geothermal providers in South Western Finland, 258,000 € might just cover the expenses of a GH investment of this magnitude.

From the earlier presented yearly profit and Turku Energia electricity CO_2 figures, an eco-efficiency calculation for geothermal heating can be performed.

$$\frac{53{,}046\ €}{284\ \frac{kg\ CO2}{MWh}} \approx 187$$

Again the same calculation is performed with the CO_2 emissions of average Finnish electricity (200 CO_2 kg/MWh). The price of electricity is not changed. The eco-efficiency ratio is as follows and the carbon footprint would shrink to 69 t CO_2.

$$\frac{53{,}046\ €}{200\ \frac{kg\ CO2}{MWh}} \approx 265$$

8.1.4 Heating Investment Eco-efficiency Analysis Conclusions

The use of eco-efficiency as an investment evaluation tool gave the results a clear environmental performance aspect. Taking both financial and ecological performances into consideration helped to create differences between the three examined alternatives as Table 1 shows.

Table 1. Round-up of the heating investment eco-efficiency analysis.

		Current provider		Average Finnish provider	
Heating method	**Cost limit (€)**	**Carbon footprint (t CO_2)**	**Eco-efficiency**	**Carbon footprint (t CO_2)**	**Eco-efficiency**
Oil	-	260	-	-	-
District	137,000	295	82	191	127
Electric	59,000	246	42	173	60
Geothermal	258,000	98	**187**	69	**265**

Interestingly enough, the best results (value in bold font in both eco-efficiency columns) would seem to stem from the potentially most costly but also environmentally best performing option. This can be seen as an example of the mindset introduced in the theory section of the thesis: investments in green rarely go wrong, especially in the long term.

Further information on the actual environmental and financial performances of the three presented and possibly other (for example woodchip and solar) heating options is needed, if an investment in this area would be considered at the factory.

This examination also shed a light on the environmental performance of Turku Energia, the current electricity supplier for Haloila, and the district heating available from it. Both offer below average environmental results when compared to average Finnish providers.

Perhaps the easiest way to reduce Haloila's factory carbon footprint would be to change the current electricity supplier to a more environmentally better performing option, if one is available with a similar or lower energy price.

8.2 Business Level Actions

An environmental aspect in a corporate philosophy can yield competitive advantages, but it will not form on its own. Below are listed four suggestions that if implemented, should set Haloila on the right track for achieving environmental competitive advantages.

8.2.1 Mission and Vision

Adding environmental statements to the mission or vision statement of Haloila should be re-considered. This would bring the eco-issues one step closer to the everyday life of the company, especially so for its management.

A statement communicating more-from-less thinking, a theme derived from the core essence of eco-efficiency, would let stakeholders know Haloila produces more products with less materials and that it generates more money with less environmental impact, both for itself and its clients.

Naturally this would be a promise to the outside world also, and as such would require actual work on the matter to begin with clearly reportable results. Otherwise there is a severe risk of harming the company's image by not living up to its vows.

8.2.2 Legitimize the Environmental Values

Environmental strategies should be brought into the everyday management of the company as another way of creating shareholder value. Each environmental initiative should increase Haloila´s competitiveness, if not, it should not be undertaken. (Strannegård 2000.)

Annual environmental performance goals set by the company management are a good way of integration eco-values to top management’s agenda (Rice 2003). Furthermore, the demand of meeting eco-targets from management can help environmental viewpoints trickle down to the employee level.

By emphasizing environmental aspects inside the company, by for example starting to use eco-efficiency in the investment decision making procedure and monitoring environmental performance of the factory on a yearly basis with the help of an eco-compass, environmental actions will be a structural part of Haloila´s and its employees’ decision-making process in the future, not just a gimmick.

8.2.3 Project Group

A project group should be formed to start the work on environmental strategies and their implementation; to begin building the new culture. Whether bringing the polygon model to life, bringing eco-efficiency into the investment routines or creating some other innovative eco-advantages to get the system running, adequate resources are needed.

Relatively quick changes inside an organization can be achieved with a project group without increasing the size of the organization in the long term. When the eco-routines are established, the group can be put back to their original tasks or moved into a new project. (Strannegård 2000.)

8.2.4 GRI Reporting

The final proposal is perhaps the most ambitious one. Aligning the company reporting with that of the Global Reporting Initiative would be a big task by any standards. What it would help to achieve on the other hand, would be a total compliance with a globally accepted environmental, social and economic responsibility reporting system, already used by some of Haloila´s biggest clients. This is something that if not implemented immediately, should be considered in the future.

9 CONCLUSIONS

In the final piece of the thesis two agendas are addressed. The first part is dedicated to contemplating the results obtained in this study; whether or not the two goals set in the beginning met.

During the writing process some thoughts on how this subject should be further studied to benefit Haloila´s environmental work arose. These ideas are presented in the second part of the chapter.

9.1 Results vs. Goals

An environmental performance monitoring tool was created for Haloila. An eco-compass represents some of the most modern thinking on the corporate ecological efficiency monitoring sector. An eco-compass will promote more-from-less thinking and signal the improvement of overall eco-efficiency at the factory, whether the result of environmental performance, process specific improvements and/or increased sales.

The company will be able to monitor the eco-performance of the factory on key environmental impact categories. 80 % of the presented categories operate with data already available to the company from their EHS reports. Publicly reporting the yearly eco-performance of the factory would send a strong signal to the stakeholders about the level of seriousness Haloila has towards becoming an ecological leader in its branch of industry.

The majority of the efforts put towards finding targets for improvement in the environmental scene were directed on the analysis of the three different substitutive heating methods for the current oil heating system.

While this led to presenting only one area for making improvements, it enabled the writer to go deep enough into the subject to be able to present a system where the material from the theory section is truly put into practice.

Applying the eco-efficiency method on the investment analysis process offers a way of combining the most basic need of a company to make good financial decisions with the ever growing need to consider the environmental issues as well.

9.2 Further Studies

To finalize the eco-compass, mass inputs from incoming materials to the factory should be obtained. Ideally the data would be automatically obtained and integrated to the current EHS system reporting. How exactly this is to be done is a matter that needs to be studied.

After the environmental performance monitoring system is fully complete, further resources can be guided towards finding areas in the factory´s operation where eco-efficiency and thus results indicated by the eco-compass can be improved. To achieve yearly improvement, this would have to be an ongoing process.

How to utilize the information from the com-compass is a topic worthy of studying. Whether to keep it as an internal eco-management tool or to go fully public with it is to be decided after a deeper analysis of the current eco-trends in the industrial scene, trends in Haloila´s line of industry and the strategy of the company itself.

How to integrate the eco-efficiency concept into other parts of a wrapping machine’s life cycle is also a theme worth researching. Achieving a level of operating within the ISO 14040-series or other globally recognized standards or guidelines should be seen as the ultimate goal.

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