Vepa - An Exploration Towards Sustainability

analysis phase
Vepa - An Exploration Towards Sustainability

Analysis Phase

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If one word could sum up the feeling of the state of society these past years that word would be “sustainability”. This word has many different meanings and applications for just as many people. In matters of finance, social cohesion and the environment, sustainability has come to take up many forms.

Just as the collapse of the world’s financial markets is a sign that the system had finally met its limits, and that it was not working in a sustainable fashion. So does it seem that the planet as an inherently sustainable system is losing its buffers and will soon pass a point where the damage it has sustained can no longer be reversed. And unlike the financial markets we cannot just inject massive amounts of capital to keep it artificially afloat. In nature, the fittest will survive. Death is neither good nor bad. It is neither strived for nor is it needlessly postponed. In this way many comparisons can be made between the functioning of the financial systems around us and the ecology of the planet. The collapse of Wall Street was a man-made problem which was the result of inadequacies of a man-made system. With the environment the story becomes more complicated however. On this the planet we are also creating man-made problems disrupting the complex system which is nature. If we see the planet as a complex system we cannot repair it using the same logic that created the problem in the first place. As Albert Einstein once said: “No problem can be solved from the same level of consciousness that created it.” Therefore, a radical new way of approaching sustainability will be needed in the future if we are to continue to “flourish” on this planet. Such a way of thinking is not gotten overnight but by a collective thought process which lately has become more driven towards environmentally sustainable ideas. The more energy and thought that goes into such solutions the closer we will get to complete sustainability. How far we can go with these words is in theory only limited by the goals we set for ourselves. However, practice shows us that it takes us time to make advances in every sector. Like the ancient Chinese proverb explains: “Even the greatest of journeys starts with a single step.”

In “Sustainability by Design” John Ehrenfeld calls these steps towards a less unsustainable world insufficient but necessary half-measures. By this he really sums up the path society must take to eventually reach a point where humans can coexist with nature while not at the same time depleting its precious resources.

“No problem can be solved from the same level of consciousness that created it.”

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1 J. Ehrenfeld, Sustainability by Design
Analysis: Summary

The project
Due to the demand from both public and private clients on manufactures to produce in an increasingly environmentally friendly way and due to a lack of strict governmental regulations it has put the manufacturers in the leading role to supply the demand for such solutions. To assist manufacturers in setting up guidelines for sustainable development some eco-labels and environmental schemes have been set-up. These guidelines provide some clarity and simplicity in the otherwise complex notion of sustainability. They also can come with a high price or not be in reach at all.

Vepa also sees the necessity to be aware of the environmental impact their products have and what they can do to minimize it. Their local and wood-based approach is something they believe already has positive environmental influences. This being the case they are interested in verifying whether their products are adequately fulfilling the demands for sustainable development, and if not, which measures need to be taken to fulfil that demand.

The process
The process begins with an investigate into the principles of sustainability both in theory and in practice. What does it mean to be sustainable?
The next step is a research into the current environmental impact of a selection of Vepa products to determine their level of sustainability. If the products do not fulfill the demands for sustainability furniture. Afterwards

The result
As this is the analysis phase the result will be the starting point for the next phase. A direction for further development shall be set-up.
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1. Introduction

For many people global climate change is a fact and with that comes a broadly carried demand for more environmentally friendly products. Nowadays, to be able to keep up with the competition, office furniture developers can no longer only focus on delivering high quality goods at competitive prices. Besides for the demand from the customers some companies also feel an obligation towards society as a whole to contribute in a positive way. This applies to both environmental and social matters. With this in mind Vepa approached the Delft University of Technology to see if a student could help in this endeavor.

In general, all of the furniture manufactures mentioned in this report have come to realize that sustainability is an issue to contend with in the sector. Some companies embrace the notion of sustainability and make it their focus point while others merely mention minimizing the impacts their products have on the environment. Whether this is done with a sincere feeling to change the business mentality towards the environment or as an advertisement technique it is sometimes difficult to say. This is one of the interesting aspects of this project. At times it can be difficult to distinguish between what companies are doing and what they are saying. Companies, however, are searching for ways to show they are sustainable, as this is becoming more of an issue with clients; demanding more environmentally friendly solutions. In this way statistics are also shown to make results transparent, however, misplaced they may seem. By either leaving out the context or excluding other dependent factors in general. What does a company include when they calculate certain sustainability characteristics? What do they leave out?

The issue of sustainability is in itself one of great complexity. John Ehrenfeld describes sustainability as the possibility for humans as a part of nature to flourish on earth forever. In other words it has nothing to do with making an engine emit less CO2. It is not about producing less bad things, but about producing more good things. In fact, the Webster-Merriam Dictionary describes sustainability as “conserving an ecological balance by avoiding the depletion of natural resources”. So, to be truly sustainable there should be a balance, in this case in nature, between the resources we use and what is available. This definition, however, is not one that is used by the general public or more specifically manufacturing companies. Sustainability has in fact no definite widely carried definition. This makes the use of the word so dependent on the user. Although it always sounds great, the word “sustainability” is almost never used “correctly”.

Problem: Vepa has no specific knowledge of the environmental impact their products have and how to improve them and can therefore take only general steps to strengthen their position in a market increasingly influenced by a demand for more sustainable solutions.

Assignment: Analyze relevant products’ environmental impact to identify possibilities for Vepa and make a (re)design of a product befitting of the goals set by the company so as to create an example for other products to follow.

Results: Product (re)design as a showcase for the company environmental goals.

The following report begins by describing the domain of the problem; the market structure and its contents. It continues with an introduction into “sustainability”. What does it mean in theory and how is this translated into practice. Afterwards a description will be given of who Vepa is and what they are doing in terms of sustainability both through general measures they take and through the execution of an Life Cycle Assessment on a number of Vepa products. Then a short competitor analysis is given. This analysis includes competitors in terms of furniture and sustainability. Also some other companies are explored as a benchmark for Vepa in terms of sustainability. This first part of the report concludes with a SWOT summary.
2. Market structure

To understand which role Vepa plays as a manufacturer of furniture, a brief description must be given of the market in which they function.

Within the market, there are three major players:
- manufactures like: Vepa, Ahrend, Assenburg, Lande, Kusch en Co., Voortman, etc.
- dealers like: PET!, KMC, ASPA, Ahrend, etc. selling single piece furniture and complete interior designs
- clients like: national and regional governmental institutions, office based companies, schools, and health care institutions.

The dealer seems to be the center of the contract furniture market. They are in direct contact with the manufacturers and buyers. They offer the manufacturers a certain turnover in return for a “lower” price. In return, Vepa gets local dealer coverage throughout the Benelux. These dealers have more local knowledge and can react quicker to any situations.

However, the dealers sell a number of different products depending on their clients’ wishes and personal focus areas or goals. The dealer can offer a selection of different products coming from different producers who all have their strengths and weaknesses.

These dealers mainly present themselves as a being a certain type of project-based office outfitter. With their specialization, comes a certain style or modus operandi.

ASPA, a large producer and seller of Vepa competitor Assenburg furniture, had (bankrupt since July 2010) as their unique selling point: building “office identity”.

According to this goal they would choose which products to buy in from different manufacturers. According to interviews with some dealers¹, Vepa's strengths are with wood panel based furniture and therefore choose Vepa when such solutions are needed.

Like many companies, Vepa chooses to work with a network of dealers throughout the Benelux. Therefore, they do not have direct contact with the clients like their largest competitors: Ahrend or Gispen who besides for being manufactures also choose to be their own “dealers” (more about them in the External Analysis). This is especially the case in the beginning stages of the process of contract furniture.

Contract negotiations are dealt with through the Key Account managers who propose certain contracts and adapt them when/if necessary. Once certain steps have been made; i.e. choice to go with a manufacturer, the key-account managers represent the manufacturers when it comes to knowledge and about production possibilities.

The dealer can therefore choose who he/she does business with according to the required solutions (price, quality, style, environmentally friendliness, etc.).

¹ Appendix 02 – Interview KMC Office Solutions Dealer
Procurement
Every (potential) client has a way of working, whether it is an office building for the government, a school or healthcare facility. As soon as a change happens within the manner of working, there could be a need for new furniture. Such a change could be anything from a move to another location, a change in style of internal functioning or the expanding of facilities due to the change in workload. These are all potential moments for a dealer to be approached to help in such a project.

However, before a dealer can be approached, the project developer, building facilitator, or anyone who has influence in such affairs must know them. This requires dealers to constantly meet as many new potential clients as possible. This is done through networking clubs, organizing seminars and other activities where potential clients are invited.

Vepa, like other producers of office furniture, in turn promote their products by inviting the dealers and (potential) clients to their showrooms and/or factory and inform them on the latest models and general developments. These general developments may include new manufacturing facilities, new partnerships, and of course any developments in the field of sustainability, ergonomics, etc. In this way Vepa once held a seminar on acoustics in office furniture by inviting experts in this field. To this day Vepa is continually confronted with acoustic related projects.

Even though the clients are placed in the center and on top in the diagram because they are the driving force in many ways, the dealers are the keystone between the manufacturers and the clients. They provide the clients with a full range of services and are backed by a broad range of products to back those services up. A short description of every party:

User – mainly employees of the client. They are the end users of the furniture.
Client – in need of service (from single piece to entire interior furnishings)
Dealer – contact point between client and manufacturers. They offer the service of being able to provide more than just the product line of one company and provide advice about the entire process of project based interior outfitting.
Manufacturer – provides a range of furniture in their interpretation. The unique selling point usually depends on the interpretation and the focus of the manufacturer.

The further one moves up in the market segments the demand for sustainability seems to increase. A company such as Steelcase and Herman Miller for example are committed to C2C and show this off. They make high quality products for the higher segments. Here the margins are higher allowing for more investment in sustainability. Companies buying such furniture have the capital power to invest in creating a progressive “green” image.

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2 Appendix 06 – Interview Dealer PET II
3. Sustainability

In order to become more sustainable, we really need to get to understand the meaning of the term. As stated in the preface John Ehrenfeld describes sustainability as a state of a system where it can continue to “flourish” forever.

“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.”

In our case it is the ability for mankind to live in balance with its surroundings. This means that any resources we take has to stay within the limit of what the ecosystem can replenish. The same applies to anything we produce; it cannot be anymore than the system can absorb. Converting too many trees, into for instance huts, will result in arid land and can cause many knock-on effects, which are very difficult to control. Such effects could include, soil erosion, landslides, bird migration (which in-turn results in an imbalance in their ecosystem resulting in yet more knock-on effects), etc.

Being sustainable, however, is something different than selling “sustainable” office furniture. How sustainability is measured, if it exists at all, and how this characteristic is marketed seem to be two sides of the same coin.

Sustainability is a complex notion and is not as straightforward as business would like it to be. It is very difficult to determine what is and what isn’t sustainable. Because of this, businesses use sustainability issues mainly as a marketing tool if it so happens to work out in their favor. If nothing is known about the sustainability of certain applications then this is usually not mentioned. Likewise if something happens to be more sustainable even though no conscious thought process making it so was involved, companies usually do not hesitate to make this clear through their communication networks.
3.1 Sustainability in theory: an LCA perspective

Life Cycle Analysis (LCA)

Although sustainability cannot necessarily be measured by an LCA it can give the starting points, namely the environmental impact. When the environmental impact is of such a magnitude that the earth can “carry” it, as explained in the introduction, then we may be able to speak of a sustainable situation. The LCA is a method to calculate (assess) the entire Life Cycle impact of a product on the environment. It factors the materials used, processes needed during fabrication, assembly, transport, use and disposal or re-use. (See appendix 08 for more information on LCA)

Although it is a very thorough evaluation of the impact a product may have to the environment throughout its lifecycle, an LCA of one product is difficult to compare with that of another, because the functionalities would have to be identical. As soon as another material is used one could argue this influences the style and thus the market for which it is intended and thus the functionality. If any functionality were different it would be like comparing apples and oranges. It remains a matter of depth however, because on the level of fruit, apples can most definitely be compared to oranges.
Carbon Footprint

Described by Vogtländer as the “Al Gore approach”, this is by far the simplest way of determining the environmental impact of a product or service. This system neglects all cases of resource depletion and all emissions except that of CO₂, due to the (widely-held) opinion that this is the (main) cause of climate change. The carbon footprint consists of two (2) parts; (1) a primary footprint and (2) a secondary footprint.

The primary footprint is the measurement of our direct emissions of greenhouse gasses (in tons of CO₂) from burning fossil fuels by using anything we have a direct control over like: driving a car, heating a house, cooking a meal, etc. The secondary footprint is caused by the any indirect emissions of CO₂ originating from the whole lifecycle of products we use. Emissions of CO₂ during resource mining, production, assembly, and the breakdown at the end-of-life are all considered in the secondary footprint.

The use of furniture results mainly in a secondary footprint because of the use phase. Since hardly any fossil fuels are burned directly as a result of the use phase it is not as relevant. Since the use phase will not have a significant role in terms of emissions would shed the most light on any environmental impact the product would

Eco-indicator 99

Eco-indicator 99 is a damage-based single score assessment. In this way one score grades the life-cycle impact on the environment. This can be done by using a sophisticated system whereby all of the emissions to air, water and soil and

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7 Vogtländer, J.G, Lecture sheets, LCA
8 www.carbonfootprint.com/carbonfootprint.html (01-06-2010)
the depletion of natural resources (LCI) are classified and characterized (i.e.: certain environmental impacts such as acidification, eutrophication, fine dust, summer smog, etc. due to certain emissions and/or resource depletion are grouped into damage categories for (1) Human Health, (2) Eco-Systems, and (3) Resource depletion) and a (subjective) weighting factor is applied to come up with a single score, called the Eco-Indicator 99.

ReCiPe

The latest development in the field of LCA calculations is ReCiPe. ReCiPe can find its origins in Eco-indicator 99. The system itself is however more complex involving an extra characterization step. ReCiPe 2008 comprises two sets of impact categories with associated sets of characterization factors. The initial LCI results translate to these mid-point calculations. Eighteen impact categories are addressed at the midpoint level: At the endpoint level, most of these midpoint impact categories are further converted and aggregated into the following three endpoint categories just like with the Eco-indicator 99. They are (1) damage to human health (HH) DALY (2) damage to ecosystem diversity (ED) (3) damage to resource availability (RA).

These scores combine to create the final ReCiPe points as a single indicator for the environmental impact of a product or service.
Eco-Costs and the EVR

Another indicator of the eco-burden is one that uses a monetary unit to express the environmental burden. In the Eco-costs system, the costs for prevention of the emissions and material use are used to determine the extent of the (possible) environmental damage. The Eco-cost is the cost that “should be made to reduce the environmental pollution and material depletion of an economy to a level which is in line with the carrying capacity of our earth”\(^9\). Instead of looking at the damage side of the story (ReCiPe, Carbon Footprint), which, especially in the case of the single score ReCiPe, there is no weighting involved with the eco-costs because no conclusions are being made on how the emissions damage the environment. The eco-costs entail the cost of prevention of the emission to air, water and soil instead of trying to quantify the damage caused by that emission.

To make LCA’s comparable the functional units of the two or more products or services one wants to compare must be identical to each other. With the eco-costs the eco-efficiency is factored in with the EVR. The EVR (Eco-Costs to Value Ratio) theory\(^10\) roughly states that products with a low Eco-cost to Value Ratio are better (less bad) for the environment. Products should have a low environmental burden when compared to the value they have for the clients.

In this case two similarly functioning products can more easily be compared. The one with a lower ratio is more eco-efficient, offering more value for the same environmental burden, or less environmental burden for the same value.

An interesting aspect of the EVR is the eco-efficiency factor. One could argue that the best way towards becoming environmentally sustainable is through eco-effectiveness; no toxic materials, only recyclable materials, renewable energy use, etc. However, recycling, for example, doesn’t always have to be better. Extending the products life so it does not (prematurely) need to be recycled could also increase its sustainability performance. This is where the EVR gets an interesting role, one that cannot be fulfilled by a single indicator alone. The EVR takes into account the aspect of creating a PSS (Product Service Systems) where by the perceived value of the product increases and thus has a better (lower) EVR. Such a service could increase the products life and therefore be perceived as being more valuable, which in turn decreases the EVR. An example would be reupholstering a chair after a certain time instead of making an entirely new chair.

This will also be the method used to analyze some Vepa products for the following reasons:

- Trend towards cost internalization of environmental burden. (i.e.: eco-tax schiphol, now also in Germany an issue.) (Waste treatment fee on household appliances.)
- Eco-costs will increase insight into (future) financial impact of design choices.
- No weighting factor/ subjectivity on what to reduce/omit.
- Comparison is possible between similar functioning products but of different quality.

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9 Vogtländer, J.G, Mestre A.C., The Eco-costs/Value Ratio for Quantitative, LCA Based, Assessment of Sustainability, 2009, pg. 4

10 Vogtländer, J.G, Mestre A.C., The Eco-Costs/Value Ratio for Quantitative, LCA Based, Assessment of Sustainability, 2009
3.2 Sustainability in practice

• “Possible” to measure sustainability.
As stated above: sustainability is a complex notion and is not as straightforward as business would like it to be. It is very difficult to determine what is and what isn’t “sustainable”. A survey\(^{11}\) shows that 88% of experts asked believe that sustainable performance leads to a stronger brand. To do something with it could therefore be seen as a wise move. The question then arises of how.

Not going deeper into the (complicated/company specific) content, a platform was created to assist companies in guiding their corporate goals when it came to sustainability. The first system introduced is one where the company is the initiator and implementer of their own goals.

The ISO standard expects the completion of the following 7 steps\(^{12}\):

1. Development of an environmental policy, in which it becomes clear that the organization is willing to set-up an EMS.
2. Establishment of an EMS.
3. Recognition and identification of the most important environmental aspects.
4. Clarification of environmental legislation, both local and national.
5. Set environmental objectives and targets.
6. Creation of programs to implement the environmental policies.
7. Evaluation of EMS to ensure improvement of environmental impact.

ISO-14000

The International Organization for Standardization came up with the ISO 14000. This standard serves as a guideline for companies to setup an environmental management system (EMS). Such a management system helps a company to implement a systematic approach in managing their activities when it comes to environmental impact.

Emas

EMAS certification, for instance, is not much more than a report showing a company’s adherence to ISO 14001\(^{13}\). Although it does go a bit further than the ISO 140001 demanding an (extra) external auditor to check if the management system is functioning, as it should.

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\(^{11}\) Globe Scan, Improving Sustainability Performance is Key to Enhancing Corporate Brand Image, 08-06-2010

\(^{12}\) www.praxiom.com/iso-14001-summary.htm

\(^{13}\) www.emas.com
General

One of the ISO standards is the 14020-25 standard for eco-labelling. ISO 14020 defines three (3) types of environmental performance labeling. This ISO standard defines the goal for these labels as: “…through communication of verifiable and accurate information, that is not misleading, on environmental aspects of products and services, to encourage the demand for and supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement”.

<table>
<thead>
<tr>
<th>Type I</th>
<th>Voluntary, multiple-criteria based, third party program that awards a license that authorizes the use of environmental labels on products indicating overall environmental preferability of a product within a particular product category based on life cycle.</th>
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<td>Type II</td>
<td>Informative environmental self-declaration claims.</td>
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<tr>
<td>Type III</td>
<td>Voluntary programs that provide quantified environmental data of a product, under pre-set categories of parameters set by a qualified third party and based on life cycle assessment, and verified by that or another qualified third party.</td>
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In general, eco-labelling is meant to continually stimulate companies to produce increasingly more environmentally friendly products while promoting these products and thus increasing their perceived market value. Eco-labeling can be for an entire product, but can also be applied to specific components in product.

Eco-label analysis and choice

Some eco-labels were compared to find standardized criteria for “environmentally friendly” development which is backed by knowledge of the environmental impact through the LCA method. Therefore some reputable Type 1 category eco-labels were taken for comparison. Type 2 was neglected because of their lack of impartiality. Type 3 is a system which classifies a product or service with a rating system like Cradle-to-cradle’s basic, silver, gold and platinum. Cradle-to-Cradle (C2C) is seen as one of the most prestigious labels and was therefore also compared.

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14 www.globalecolabelling.net/whatis.html
Eco-labels: a summary

Total product transparency is mandatory for all eco-labels (European eco-label: the Flower, the Nordic Swan, the Blue Angel, C2C). Material identification and classification are important steps towards environmental improvement. The materials can be systematically evaluated and if need be replaced/improved upon. For the complete lists ordered in material group see the appendix15. The Nordic Swan, European Eco-label: the Flower, and the Blue Angel use product categories and have underlying specific criteria. This is one of the big differences between this group and the C2C label.

The C2C label is set up in such a way that really any product category applies. The other major difference is the expanded integration of manufacturing criteria, like, regulations for water processing, (type of) energy use, etc. that the other above mentioned criteria do not have. For the C2C platinum label a leading role is required in terms of resource reduction, reuse, and reclamation. Whereby the manufacturer is asked to supply innovative solutions when it comes to the quality of water. The Nordic Swan and European Flower require the amount of energy used during production to be below a certain amount according to their own formula (see Nordic Swan criteria: R11) but has no requirements in terms of energy origin. Der Blaue Engel mentions no such requirements in either of the two documents researched: RAL-UZ 38 and 117. With C2C the origin is key. The highest rating demands 50% of energy required for total production (excl. transport) to originate from renewable resources. The total amount used is apparently of no consequence.

In the highest rating the C2C label even demands certain social involvement by the producer. (These social criteria are not a part of this research)

With regards to the chemical products (mainly) used as a surface treatments. The CAS numbers on the MSDS (Material Safety Data Sheets) will need to be compared to the restricted substances according to the eco-label. Besides this the following criteria apply:

15 Appendix 09 - Eco-labels and criteria
Wood
Sustainable forestry practices are ensured when the wood or wood based products carry either of these logos: PEFC/FSC. This is a mandatory criterion for Nordic Swan, European Eco-label, Blaue Engel and C2C.

The Nordic swan allows both E0 and E1 to qualify. Der Blaue Engel permits only E0. C2C has no criteria for E0 or E1 but uses the California 01350 standard of one half the REL of 33 micrograms/m3: 16.5 micrograms/m3.

Fabric
The use of the Oeko-Tex® Standard 100 label can ensure environmentally friendly fabric without the use of heavy metals for dyes. The criteria also exclude halogenated flame-retardants, azo dyes that may cleave to carcinogenic acrylamines, carcinogenically and mutagenically classified dyes, or those harmful to the reproductive system.

This label is accepted for the fulfillment of Der Blaue Engel logo when it comes to the standards they set for fabrics.

Hazardous materials (Blaue engel, Nordic Swan, European Ecolabel, C2C)

Padding materials
- Partially fluorinated hydrocarbons (HFCs),
- perfluorinated hydrocarbons (PFCs),
- partially halogenated chlorofluorocarbons (H-CFC),
- chlorofluorocarbons (CFCs) or
- methylene chloride

Coating systems (banned emission levels)
- >250 g/l VOC (2-dimensional surface) (Blaue Engel)
- >420 g/l VOC (3-dimensional surface) (Blaue Engel)
- >0.5 mg/m3 TVOC (C2C)

Fabric dyes
- cadmium, mercury, lead or nickel

Pigments and additives based on:
- lead, cadmium, chrome (VI), mercury and their compounds
- arsenic, boron and copper
- organic tin

Leather tanning (banned levels)
- >CrVI 3mg/kg (C2C: complete ban)

Flame retardants
- inorganic ammonium phosphates (ammonium hydrogen phosphate, ammonium polyphosphate etc.),
- boron compounds (boric acid, borates) or other
- dehydrating minerals (aluminium trihydrate)
- material protection agents (fungicides, insecticides, flame-retardants)
- halogenated organic compounds
- phthalates,

Halogenated organic binding agents,
- azidin and
- polyaziridins
- General hazardous materials (See Appendix - Eco-labels and criteria)
Summary: C2C
General guidelines
• use of certain materials,
• no hazardous materials (see specific lists in criteria),
• maximize renewable resources,
• keep materials as virgin as possible (i.e. No additives, no surface treatment if possible, separable)
• maximize use of recycled materials
• maximize recyclability by Design for Disassembly and Recyclability.
• no PVC
• no heavy metals at any level for highest ratings
• no transportation guidelines
• Renewable energy guidelines applicable at different levels for different certifications. Highest rating demands 50% of all energy through production and assembly to be green.
• no limit of energy use

Summary: Nordic Swan, European label, Der Blaue Engel
General guidelines
• use of certain materials,
• minimize hazardous materials (see specific lists in criteria),
• maximize renewable resources,
• keep materials as virgin as possible (i.e. No additives, no surface treatment if possible, separable)
• maximize use of recycled materials
• maximize recyclability by Design for Disassembly and Recyclability
• no Chrome VI, only Chrome III
• energy use limited
• no transportation guidelines
4. Internal Analysis

In this section Vepa will be examined more closely. A short description will be given of the corporate structure, core competences, who their clients are and what their goals are when working with them. The second part of this internal analysis puts the focus on the topic of this report. A description is given of what (general) steps Vepa is taking now in terms of sustainability and this section will conclude with an LCA analysis of a number of Vepa products.

4.1 Company structure

In general, Vepa can be characterized by having a horizontal company structure. This is partly due to its size, approximately 111 employees\(^\text{16}\), but also due to the culture of the region. The area (the northeastern part of the Netherlands) is known throughout the Netherlands for its inhabitants and their down to earth mentality. The size and structure of the company are the main factors, which make the company less rigid and more flexible for adaptation and change in general. This was recognized through interviews and during regular conversation with employees. It is therefore not only an attribute described by the director of the company but also a personal finding gained through dialogue with the employees personally.

All of the departments are more or less found in one area of the company. The only exception being is the factory for obvious reasons and the different departments within. All other departments are well connected to each other allowing for relatively easy communication. This open structure with the work desk dividers functioning literally as low thresholds for communication reduces the figurative threshold for inter- and intradepartmental communication. This allows company employees to easily contact each other and discuss any problems. It is therefore not uncommon to have a number of employees, all from different departments, discussing on certain issues together.

\(^{16}\) Internal document, Kernactiviteiten, Organisatiestructuur 2008, pg. 4
To the right the corporate layout is displayed. With the managing director being head of sales.
After a client has been “won” a plan will be drawn up according to the wishes of the client. This is then discussed with product development and accordingly a plan is setup depending on the needs of the client. The plans go from the design team to pre-production who together with the head of inventory oversee whether or not the design is fit to be produced according to the manufacturing capabilities. Together these two departments go through an optimization process until the design is such that it can be made efficiently. At about this point the head of inventory starts ordering the needed supplies and materials. After which work on the order can start. The design process is illustrated in the center of the diagram. The circle starts and ends with the client. The circle is unbroken due to the fact that the relationship between the parties continues far after the initial delivery of the products.
Although Vepa can supply a client with an entire interior solution it is mainly a producer of wooden office cabinets, work desk, tables and steel frame chairs that contain some wooden (molded plywood) element in the seat and or backrest. Using the products of others within the VDB Group allows them to offer a complete solution when desirable. The following is a quick overview of the types of products Vepa produces.

**Cabinets & closets**

Cabinets and closets are primarily produced using particleboard. The frame is made up of particleboard with an outer layer of melamine, which is available in a certain number of colors and patterns. The fronts are usually made of the same particleboard with melamine, however this can also be a layer of HPL (High Pressure Laminate) or veneer. When it comes to the HPL the client can choose for a number of patterns. These can include any wood grain desired, but also floral patterns or any other print, which is available. The HPL also has the added value of extra toughness of the finish. The HPL is considerably more scratch resistant then the melamine version. Variations are also possible when it comes to different acoustic properties that, if requested, can be integrated into the cabinet doors.

The cabinet components are then prepared for further assembly. After the frame is assembled, the hinges, doors, and, if requested, locking system is assembled. Afterwards they are prepared for shipping to their final location.

4.2 Core competences
Desks & tables
These desks are also primarily produced using either MDF (Medium Density Fiberboard) or particleboard. Depending on the chosen design different materials will be used.
The panels can be made in two ways. The first way is as a single layer of board approximately 15 mm thick. The second way is with a sandwich construction whereby the two pieces of board are separated with a cardboard honeycomb inside layer, creating extra strength while reducing weight.
Depending on the clients’ wishes different variations can be made.
The top layers can again have a melamine finish (bottom), a HPL finish or veneer (bottom right); each having their own physical and aesthetic functions.
Integrating height adjustment possibilities (top right) is something that has become a part of the design culture and is now accepted as a must.17 Electrical sockets and network connections both belong to the possibilities of the product lines.

Tables are more or less a simplified version of desks. They are built up out of an epoxy or chrome steel frame, on top of which the tabletop is placed. The tabletop is also available in the same materials as the desks; particleboard with HPL, volkern (thick HPL), melamine or veneer.

17 Appendix 02 - Interview Key Account manager
Chairs

The construction of the chairs also involves some wood, but less in proportion than that of the cabinets. This can partly be explained by the following reasons. The first is that the market seems to have an attachment with this style of seating (market pull). The compilation of chairs below produced by various manufactures such as Ahrend, Arper, Casala, Gelderland, Gispen, Kusch en Co, Lande, VDS (Van der Sluis), Vepa, and Vitra demonstrates the similarities between the chairs. Second it is a strong and proven method for chair fabrication (manufacturer push). Since the turn of the century chairs have become more commonly made of tubular steel. This is especially the case in the professional market. The versatility and strength of steel are welcome attributes where architectural transparency and strength are strived for.

Vepa mainly makes chair frames using steel tubing. The tubes are bent and welded into place on sight in Hoogeveen. Afterwards the frames are prepared for their finishing coat. Color coating is done on-sight using powder-coating installations where almost all of the powder-coating material is recycled. Frames to be chromed are sent off-sight to a chromery nearby (70km) in Gorredijk. Vepa will usually buy in molded seats of beech with steel inserts for the attachment to the frame, which will then be upholstered or finished in Hoogeveen. If no upholstering is required a higher quality wooden panel is selected after which it is painted with a transparent or colored finish. If upholstering is required it can be done to the client’s specification. A certain color may be requested (fitting with a certain company image) where after this can be ordered instead of using in stock colors. This follows a number of steps. The fabric is cut to shape and sawn to the required form. Depending on the model, the foam (precut by supplier) is glued to the seat and/or backrest. The fabric covers the seat and is either stapled to the bottom where an extra sheet of thin cotton “fibertex” neatly hides the covering’s edges or the upholstering is finished by saving it shut. Afterwards the seat is ready for final assembly. Any additional parts like, plastic stackers, plastic feet, etc. are added. Finally, the seats are prepared for transport by covering them in a protective LDPE bag and stacked in the loading dock.
Vepa showroom in Hoogeveen
Supplementary products

**Workspace dividers**
As stated in the beginning of this section Vepa does not produce all of the products it sells. One of these products is a modular space divider.
To ensure a feeling of privacy and/or (acoustic) comfort clients may prefer to install space dividers for a workstation. These space dividers seem to be simple office installations. However, due to its modularity many functions can be integrated. Organizers, electrical sockets, magnetic strips are but a few of the options to be included in a solution. Being modular makes almost any combination possible.
In contrast to the acoustic properties of the cabinets and closets, the possibilities are much greater here. As can be seen in the picture on the right many different types of walls are available. They vary in thickness, hardness and thus in acoustic damping.

**Office chairs**
Another product group which Vepa does not produce themselves is that of the office chairs. Two are offered on the website. This is also done to be able to offer a complete solution.
4.3 Clients

Vepa has extensive experience in both large and small orders. They have the ability to provide anything from a single desk for a director’s office up to an entire office interior with hundreds of workstations.

Some examples are projects for municipal buildings in Zwolle, Meppel and Vianen, offices for companies such as Achmea, Office Depot and Tennet, churches in Emmen and Delft and even an auditorium in Arnhem with 840 seats (below).

Demand for sustainable solutions

According to an interview\(^{18}\) with a dealer from PET the demand for sustainable solutions come from companies who are able to make a statement when it comes to showing their “green” image. Companies like Achmea and Rabobank are two companies mentioned who are interested in such solutions.

\(^{18}\) Appendix 06 - Interview Dealer PET II
Vepa is owned by six (6) family shareholders\textsuperscript{19}. This control over the company allows them to make the decisions about how the company should be run. This also means that they decide on the desired characteristics of such a company. One of these characteristics is the demand for consistency. This can partially be seen in the directing manager’s 35-year tenure. But more clearly in the strong financial figures the company has produced in the past\textsuperscript{20}. This also means that long-term strategy gets the priority over short-term gains. This is also demonstrated by the efforts made by acquisition to become the main furniture supplier\textsuperscript{21} for companies who would be interested in doing business with Vepa for the long term.

With this project Vepa aims to show their commitment in actively searching for solutions in the realm of sustainable furniture manufacturing. In short, it is a company set for the long run. This long-term-based mind-set combined with the level-headedness that is Vepa’s own results in a rather distinct attitude towards sustainability as a matter of corporate responsibility and as a matter of market place success.

\textsuperscript{19} Vepa Sustainability Report 2010, pg. 6  
\textsuperscript{20} Vepa 2009 annual report, pg. 3  
\textsuperscript{21} Appendix 02 - Interview with Key Account manager
Vepa and sustainability

Most of the manufacturers within the sector of middle-to-high-end office furniture, like Vepa, are busy with sustainability in one way or another. They all have realized that it is an issue that can no longer be avoided. It is a topic which is treated differently by all of the players, as will be explained in the external analysis section. Vepa is well aware that something should be done with respect to sustainable product development. With this they would at least maintain but preferably strengthen their market position. However, their levelheaded mind-set does prefer them to make real measurable improvements, which they can show their clients. They want to show real results instead of only marketing company figures in a way that displays environmental sustainability.
Materials

Vepa - in their perception - has already taken the right step in designing for sustainability with their choice for wood based furniture.

It is the company’s view\(^\text{22}\) that wood is a more sustainable material than steel and chooses therefore to focus more on dealing with this renewable resource.

The reason behind this is that wood, purely as a material, has less “embodied energy” than steel or plastics. According to an article in Preservation magazine the “embodied energy is the energy required to extract, process, manufacture, transport, and install building materials”\(^\text{23}\).

Steel has 32MJ/kg where particleboard only has 8.2MJ/kg\(^\text{24}\). Although this concept of (partially) measuring sustainability is used more commonly in construction, as it is included in the LEED (Leadership in Energy & Environmental Design) certification\(^\text{25}\), some parallels may be drawn to product development. No real comparisons on volume, weight, functionality or other factors influencing sustainability have been made though.

There are, however, limitations to using wood in furniture, especially in chairs where the construction is more transparent and the demand for strength and weight are more of a conflict than with cabinets that, in essence, do not need to be moved after they have been put into place. The chairs on the left are more befitting a care home where the physical demands of the chairs may be higher. In this the frame and the back legs are both of steel.

\(^{22}\) Vepa presentation on company sustainability policy.
\(^{24}\) Internet site: http://www.canadianarchitect.com/asf/perspectives_sustainablity/measures_of_sustainablity/ measures_of_sustainablity_embodied.htm
\(^{25}\) Internet site: http://en.wikipedia.org/wiki/Embodied_energy
Key issues
According to a Vepa employee a big problem in terms of sustainability is the PUR foam seating solution. First of all, the foam itself; it is non-recyclable as a raw material. It can really only be down-cycled. Secondly it is sometimes (depending on the model) glued to the wooden seat to prevent sliding. This now makes the wooden seat, also non-recyclable. The application of HPL or other plastic materials glued to particleboard is also an issue in terms of sustainability.
Many of the restricted materials in the eco-labels have to do with materials involved in these types of applications (blowing agents and adhesives.)

Manufacturing
Unlike their main rival Ahrend, Vepa in-sources most of their manufacturing needed. This gives Vepa a number of advantages in terms of material processing and waste reduction. They make their own tabletops unlike Ahrend26 who out-sources this step. The company already selects the size of pre-cut sheeting depending on the required size afterwards. This is especially the case for large orders of entire decors. This inhouse manufacturing also gives many possibilities in terms of C2C criteria, where by it would be easier to ensure the use of a certain type of electricity provider throughout the manufacturing process.

26 Appendix 01 - Interview Vepa employee
Another advantage of in-sourcing manufacturing steps is the effect it has on the emissions due to transport. The closer the product is manufactured (assembled) to the end user, the more efficient the transport is. This is the case with all of the steps needed to be taken to make the products. An example is the upholstering department. Since the final sewing and making of the seat and backrests is done in-house the materials can be bought in on a larger (bulk), more efficient scale. All materials come into a central point (Vepa) after which they are assembled and then directly sent to the client or dealer. In a structure where many suppliers are involved supplying to, not only the final manufacturer (Ahrend) but also to sub-suppliers (table top maker, or seat upholsterer) and then finally to the manufacturer for final assembly extra transportation steps are needed with the extra emissions that come with it.

Vepa uses blankets as a reusable material to protect cabinets, tables, desks and chairs. An LDPE covering is also used as extra protection for the chairs. It is asked at delivery if the plastic should be removed. This is not always done. Any bags that are good enough to be used again are, however, the bulk is recycled, unless other garbage is deposited in them. (i.e.: bags are sometimes used as garbage bags during installation of furniture.)

Vepa also maximizes the use of European materials. The steel is purchased form Corus in IJmuiden, the Netherlands and the wood is in the worst case imported from Eastern Europe (+/- 1500 km). Choosing to be active in the Benelux their entire functioning area is also smaller.

Being a multinational like Ahrend or Herman Miller can bring negative effects in terms of transport depending on the location of facilities. The Herman Miller website also boasts a 35% air travel reduction last year due to extra video
conferencing facilities. But the choice to become a multinational inherently brings with it the need for air travel in the first place and consequently the use of extra technology in the form of video conferencing facilities, etc.

**End of Life**

The situation at the End-of-Life of office furniture is not clear. The products are assembled in such a way that they can be taken apart with ordinary tools, however if and when this happens remains unclear. It is known that furniture usually outlives its physical life however the aesthetics are something which makes the product no longer “adequate”. Products are sold on to others or given away.

In terms of waste produced on site, Vepa has a direct benefit when reducing and separating the waste. This is why a scheme has been initiated to more streamline this waste management (see top picture). According to Vepa employee, discipline is really the only barrier between optimal use of waste management system in place. The observation which resulted in these pictures also found several containers containing wood and trash mixes. Even if 5% of the waste is disposed at the higher price bracket (6.1 tons at 95 €/ton)\(^{27}\) than the result is approximately a loss of 480 euro’s per year\(^{28}\). Financially speaking, seemingly non-significant.

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\(^{27}\) Price list waste disposal by Van Gansewinkel (internal document)

\(^{28}\) This also accounts for the fact that it would have been disposed of at the correct rate of 16 €/ton. Calculation excludes the transport costs, which are applicable for the higher price bracket and is not the case for the disposal of wood.
4.5 LCA Results/Conclusions

To get an overview of how sustainable Vepa’s products are and in which ways they could be improved, it is necessary to do an environmental impact analysis on a selection of products. The analysis results are shown in the graphs provided in the Excel sheet printouts[^29]. The graphs below are the most significant findings and provide insight into the environmental impact of the Vepa products selected:

1. Chairs: Alpine-10, -50, Cosmo
2. Table T-30, several variations
3. Cabinet: K-Store; one version

Additionally, some perspective is provided by 3 competing products with “sustainable” features:

1. Chairs: Ahrend 360 Beech and Polypropylene
2. Table: Ahrend Philink table: Steel legs and Bamboo tabletop
3. Cabinet: Fake Steel cabinet: Same dimensions as K-Store using 0.6 mm steel.

The first two graphs shown are first of the Eco-cost and ReCiPe pts calculation during the “Base-Case” for the chairs. If the Base case was the true identifier of the environmental impact than the Vepa chairs analyzed would most likely be the better choice.

[^29]: Appendix 08 - LCA Results of Vepa Products
However, when recycling, instead of disposal to the landfill, is calculated for the “Best-Case” scenario the results are reversed. The Ahrend 360 made with PP seat arrangement has the best recyclability (material choice) and therefore scores the highest during the best case scenario with a total of € 2.15 of eco-costs and 1.81 ReCiPe points. The best scoring Vepa chair is the Alpine 10 with clear finish and powder coated frame with € 3.12 in eco-costs and 2.01 ReCiPe points.

The graphs clearly show the importance of recycling and the effects of the different end of life scenarios.

The “Base-Case” is relevant because of the fact that it has not occurred and the future is simply unknown. Depending on the End-of-Life scenario a product can earn “recycling-credits”. This stipulates the importance of a good take-back policy (See Interface, Senator (furniture in general), BMA, Herman Miller) or regional recycling program to finally receive payback in the form of these credits.

To increase potential for recycling while not taking exaggerated risks in material choice: This is the case for magnesium if it is/can not (be) recycled. The Ahrend 360 chairs therefore have much higher scores than the Vepa chairs, however their potential (seen in orange) is much greater. The same is the case when looking at the difference between the Alpine 10/50 and the Cosmo. It is the aluminum in the Alpine chair that gives them more potential for recycling. This larger potential has to do with the lower melting temperatures (higher recyclability) and decreased demand for burdensome virgin material.

The optimist would see the potential for recycling and the added benefits when it

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30 Extra research would need to be done on these take-back policies of theses companies to see what the advantages and disadvantages are. Some companies have them but as is the case for a “front-runner” like Herman Miller, it is doubtful whether such a system is viable. This is partially the reason why some companies boast of cooperation with waste management companies; i.e. looks like they are doing something about it. However, does a company exist that does not work with a waste disposal company?
occurs. The pessimist would see the potential disaster around the corner. Taking such risks should therefore only be done when it is sure that recycling is possible and will occur. The stimulation for recycling of products should therefore always be a priority. Some management system to guide the process of end-of-life could be an interesting way to keep the user informed about the recycling possibilities.

**Material choice**

The materials are by far the biggest contributors of the eco-burden. This is the case for every indicator used. The Eco-costs and ReCiPe points are usually quite consistent in that they seem to fluctuate evenly for different materials. The case for plywood is different however. According to ReCiPe plywood has a relatively high eco-burden. This eco-burden is due to a proportionally high eco-toxicity (one of three end-point values for ReCiPe) value for plywood. In the other two factors determining the final ReCiPe score (Human health and Materials depletion) plywood scores lower than ply bamboo. The answer can be found in the LCI and the ReCiPe calculation done in SimaPro. This should be done with an expert in SimaPro (in the future).

The top layer is influential in the final score for the tables. The tables (right) with HPL and volkern both score relatively high when compared to the veneer table and the Ahrend Philink. This is especially the case with the volkern. The eco-burden in terms of Eco-cost and ReCiPe points is higher than the steel in the frame. The eco-burden of volkern when compared to the other options seems conclusive.

The “Best-Case scenario” shows no significant difference in the outcomes due to similar recycling and incineration potential of all of the tables analyzed.

The overall choice of materials and the fact that the travelled distance is relatively smaller (transport for bamboo from China is included in the LCA of Ply bamboo, See appendix) results in the Ahrend Philink having the lowest Eco-costs (Best Case:}
€ 7.95, Base Case: € 14.17) and ReCiPe points (Best Case: 2.334, Base Case: 3.936) when compared to the second lowest, T-30 table with melamine and powder coated frame with Eco-costs of (Best Case) € 9.01, and (Base Case) € 14.81 and Recipe points of (Best-case) 3.248 and (Base-Case) 4.796.

**Material use**
The self-supporting Ahrend table uses the strength of ply bamboo instead of steel to support itself. This results in approximately a 60% reduction of steel when compared to the Vepa T-30. This can clearly be seen in the graph on the right where the materials are displayed separately. In this case, reduction of materials is obtained through good material choice. The effect on cost would need to be investigated, but by saving in one area while investing on another the result may be neutral in terms of costs while decreasing the impact on the environment.

**Transportation**
Transport impact is most significant at the end of the chain. This is because of two compounding factors.
- Distance between Vepa and Client is relatively far (approximately 100 km farther than that of Ahrend to the client)
- Size of final product.
This is especially the case with tables and cabinets, which are not stackable.
In practice, though, products are well placed in the trucks trying to optimize the space available. While the spaces under and above tables are used for other products, a conversation with a Vepa employee involved in loading the trucks disclosed that the space within cabinets was not fully used however. This was done to minimize the risk of scratching and damaging.
Keeping the supplier location for Vepa and Ahrend the same results in some better figures for Ahrend due to their more central location\(^{31}\) in the Netherlands.

**Materials and processes**

Ideally a model should be created out of which a direct cause effect relationship becomes clear between the material used and subsequent process needed. However, it is apparent in the calculations that the materials are by far the most leading aspects of the environmental impact. Changing the way a table or a cabinet can be brought to the final location would have a more significant impact (see previous paragraph) than changing the process. In general is it very hard to make a distinction here. Using volkern, for example takes less processing in general, but as a material is clearly worse. Besides this, the accuracy of this LCA may not be great enough to make any conclusive remarks on the relationship between the material and processes. For this a broader study of many types of products with similar material may need to be done. With all choices made one should remember the three R’s of Reduce, Reuse, Recycle. A change in design could lead to less cutting or welding or processing in general.

\(^{31}\) Appendix 08 - LCA of Vepa products
Something that is interesting although not unexpected is the “less positive” effect of recycling. We see that when a significant amount of plastic (Ahrend 360 PP seat) is recycled the total CED value (for the entire product) is higher than when compared to incineration. This makes sense because incineration generates energy, which can be seen as credits (negative) that are higher than the credits for recycling would be. So when looking only at the CED the result can be different. This also demonstrates the difference between a single issue (Carbon Footprint, CED) and multi-issue indicator (Eco-Costs, ReCiPe) whereby in this case no score is given for material depletion impact (purpose for recycling), which is exactly the impact category in ReCiPe that has the highest score (only negative score) when compared to the effects on eco-toxicity and human health.
4.6 Sustainability of Vepa Products

With the environmental impact known the sustainability\textsuperscript{32} of the products can be determined. For this the EVR will be calculated and compared to what is considered to be a sustainable level. To achieve “sustainable” office furniture the EVR must be 0.065\textsuperscript{33} or lower for wooden office furniture and 0.082 or lower for office furniture not containing wood. As can be seen there is no EVR above 0.055.

Furthermore, these EVR’s are “cradle-to-grave” which means they include transport to the final location and the “Base-Case” end-of-life scenario, which is not included in the “norm” EVR which are “cradle-to-gate”\textsuperscript{34}, meaning they are based on LCA calculations up to the point of sale. In this case no end-of-life scenario is applied which, as can be seen in the LCA, can have a large influence on the final outcome.

In the table it can be seen that not one product has an EVR which fails to reach the goal set by Vogtländer\textsuperscript{35} which would be a realization of a 50% reduction in CO2 emissions when compared to current emissions.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|l|c|c|}
\hline
Product & End-of-Life & Description & Eco-costs & Price & EVR \\
\hline
Alpine 10 & Scenario 0 & Base Case & 7.402 & € 250.00 & 0.030 \\
Alpine 10 & Scenario 1 & Incineration and recycling & 3.118 & € 250.00 & 0.012 \\
Alpine 10 & Scenario 2 & Landfill and Recycling & 6.733 & € 250.00 & 0.027 \\
\hline
Alpine 50 & Scenario 0 & Base Case & 10.630 & € 441.00 & 0.024 \\
Alpine 50 & Scenario 1 & Incineration and recycling & 5.946 & € 441.00 & 0.013 \\
Alpine 50 & Scenario 2 & Landfill and Recycling & 6.565 & € 441.00 & 0.015 \\
\hline
Cosmo & Scenario 0 & Base Case & 9.262 & € 366.00 & 0.025 \\
Cosmo & Scenario 1 & Incineration and recycling & 7.039 & € 366.00 & 0.019 \\
Cosmo & Scenario 2 & Landfill and Recycling & 7.773 & € 366.00 & 0.021 \\
\hline
T-30 Fin en Ch. & Scenario 0 & Base Case & 15.722 & € 535.00 & 0.029 \\
T-30 Fin en Ch. & Scenario 1 & Incineration and recycling & 9.739 & € 535.00 & 0.018 \\
T-30 Fin en Ch. & Scenario 2 & Landfill and Recycling & 12.591 & € 535.00 & 0.024 \\
\hline
T-30 Melamine & Scenario 0 & Base Case & 14.810 & € 271.00 & 0.055 \\
T-30 Melamine & Scenario 1 & Incineration and recycling & 9.009 & € 271.00 & 0.033 \\
T-30 Melamine & Scenario 2 & Landfill and recycling & 11.680 & € 271.00 & 0.043 \\
\hline
T-30 HPL & Scenario 0 & Base Case & 15.727 & € 374.00 & 0.042 \\
T-30 HPL & Scenario 1 & Incineration and recycling & 9.473 & € 374.00 & 0.025 \\
T-30 HPL & Scenario 2 & Landfill and recycling & 12.597 & € 374.00 & 0.034 \\
\hline
T-30 Volkern & Scenario 0 & Base Case & 20.167 & € 408.00 & 0.049 \\
T-30 Volkern & Scenario 1 & Incineration and recycling & 11.881 & € 408.00 & 0.029 \\
T-30 Volkern & Scenario 2 & Landfill and recycling & 17.037 & € 408.00 & 0.042 \\
\hline
K-Store & Scenario 0 & Base Case & 18.270 & € 928.00 & 0.020 \\
K-Store & Scenario 1 & Incineration and recycling & 13.232 & € 928.00 & 0.014 \\
K-Store & Scenario 2 & Landfill and recycling & 17.721 & € 928.00 & 0.019 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{32} Within the earth’s carrying capacity
\textsuperscript{33} Appendix – 08, LCA of Vepa Products
\textsuperscript{34} Appendix – 08, LCA of Vepa Products
\textsuperscript{35} www.ecocostsvalue.com/httpdocs/content/html/startpagina/startpag_1.html
Conclusions EVR

The obvious conclusion here would be that even during the “Base-Case” scenario the furniture could be classified as being “sustainable”. At first glance this would seem to be a very good thing, however, the EIPRO report\(^\text{36}\) does not disclose the price of the furniture, an essential part of the EVR. If the prices are relatively low than the supposed “norm” is relatively high. This being the case than the possibility of any brand’s furniture being “sustainable” may be more likely.

Even if the prices of the Vepa furniture is comparable to that of the furniture used in the EIPRO report, the factor of 6.43 assumed to be enough to bring the earth’s CO2 levels to below the threshold level and thus preventing global warming may not be high enough. This was also based on the assumption that a 50% reduction in CO2 would be enough to mitigate global warming with a population increase factor of 1.56 over the next 90 years.

Unfortunately it is therefore very difficult to tell how “sustainable” the products are.

\(^{36}\) Appendix – 08, LCA Vepa Products pg. 14
This section is an overview of the market; the playing field for Vepa. Who are Vepa’s main competitors and what are they competing on? How big is the market and what role does Vepa play in it? This section also includes a number of (furniture) companies who are especially active in the field of sustainability. They are also shortly described below.

5.1 Competitors (office furniture)
The main competitors of Vepa are those companies offering similar services in the same region. These companies include:

- Koninklijke Ahrend N.V. (market leader)
- ASPA Office Identity / Assenburg Office Furniture (formerly known as Samas)
- Gispen
- Voortman, Wilkhahn, Kusch & Co., Lande, Gelderland (all not discussed here)
- Haworth (one showroom in NL; main focus US)
- Herman Miller (Sustainability benchmarker)

It is however difficult to find information on all of the companies. The main competitor due to size in sales but also due to reputation on sustainability issues is widely considered to be Ahrend. Below an overview is given of the financial situation of Vepa and the main competitors. The most useful figures are those showing the market share (Net Sales) and the ability of making a profit (Net result). The number of employees making the net sales possible can also give some in sight on how productive those employees are. Due to the economic downturn the past
years Ahrend\textsuperscript{38} has had to relieve 140 (almost 14\%) employees spread over both manufacturing facilities and some other financial and support functions as of March of 2009.

### Important figures 2008 (2007)

<table>
<thead>
<tr>
<th>Company</th>
<th>Net Sales* (revenue)</th>
<th>Net result*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vepa (source: Vepa 2009 annual report)</td>
<td>€20.3</td>
<td>€2.32</td>
</tr>
<tr>
<td>VDB Group (source: <a href="http://www.cromes.nl">www.cromes.nl</a>, 2-04-10)</td>
<td>€50-60</td>
<td></td>
</tr>
<tr>
<td>Ahrend (source: Ahrend 2008 annual report)</td>
<td>€157.7</td>
<td>€1.08</td>
</tr>
<tr>
<td>Gispen Lensvelt Groep (source: ...)</td>
<td>€62</td>
<td></td>
</tr>
<tr>
<td>Haworth (source: <a href="http://www.haworth.com">www.haworth.com</a>, 29-04-10)</td>
<td>$1,650 (worldwide)</td>
<td></td>
</tr>
<tr>
<td>Steelcase (source: Steelcase 2009 annual report)</td>
<td>$3,420 (worldwide)</td>
<td>$133.2</td>
</tr>
<tr>
<td>Herman Miller (source: Herman Miller 2009 annual report)</td>
<td>$2,012</td>
<td>$152.3</td>
</tr>
</tbody>
</table>

*in millions

\textsuperscript{38} Ahrend annual report 2009
As market leader (30% of furniture market and 10% for office furniture:1999) Ahrend seems to be the main competitor in terms of quality, price, type of clients and single-sale volume. They, like Vepa, provide a full range of services starting at consultation about interior design and ending with after-sales of services rendered. They, unlike Vepa, bypass the dealers and negotiate directly to the client. They are therefore not only a competitor for Vepa in the manufacturing sense, but also a competitor for the dealer. Dealers have an advantage in that they can offer a broader array of furniture to more specifically address the needs of the client.

Ahrend focusses on collaboration with architects and design studios to produce products with high standing aesthetic qualities. Some names involved in recent collaborative projects are FLEX/the INNOVATIONLAB, Voet Theuns Architects, Rudy Uytenhaak Architecture Firm, Meyer & Van Schooten Architects and Herman Hertzberger. Ahrend has worked in the past with designers like, among others: Friso Kramer, Frans de la Haye and Ruud Jan Kokke.

Classic designs such as Friso Kramer’s Revolt (1953) has even been reintroduced in 2004 and remains to be a member of the Ahrend collection.

It can thus be said that Ahrend focuses on the aesthetics of its products and therefore collaborates with well-founded and also up-and-coming designers on a frequent basis. This provides for both fresh and new developments with surprising results but also trusted designs proven by the test of time.

To obtain more integration between the producer and consumer Ahrend has started a platform named: “Co_Create NOW”. This scheme is supposed to integrate like-minded individuals or institutions to create a product, which more represents the
needs of those involved. In general, not dissimilar to the Vepa “Inspired by You” slogan. Both approaches stimulate involvement of dependent parties resulting in what is hoped to be a more thought-out solution.

Of the companies compared here Ahrend has the biggest product line. To supplement their chair line, they sell a number of products from Allsteel.

**Ahrend and sustainability**

Ahrend seems to be very busy with sustainability; collaboration with C2C, van Gansewinkel, EcoSmart and an EMAS Certification.

An example is the material choice of a new chair made by FLEX/thelINNOVATIONLAB for Ahrend: the Ahrend 360. The argument is that magnesium is light in weight and requires a lower temperature to melt than aluminum or steel, thus “advantageous in energy consumption during production”\(^\text{41}\). In this case however, if the theory of embodied energy is applied magnesium is off the scale with its (depending on the type involved) 334 to 460 MJ\(^\text{42}\) of energy used to extract, process, manufacture, transport one kilogram where steel only takes one-tenth of the energy. An LCA calculation was executed using the information available on the website and knowledge of the company. To see the full LCA go to the LCA of Vepa products in the Internal Analysis on page 32.

Another example Ahrend “philink” table, designed by Voet Theuns Architects. Ahrend regards their solution as “…ecologically sensible due to its self-supporting top made of sustainably cultivated giant bamboo.” However, a study done by Pablo van der Lugt\(^\text{43}\) has shown bamboo to be less sustainable than the use of soft wood which can be collected within Europe and it can be known to be less “People”

\(^1\) http://www.ahrend.nl/smartsite.dws?language=EN&ch=COM&id=93304
\(^2\) CES, Cambridge Engineering Selector, 2009
\(^3\) van der Lugt, P., Design Interventions for Stimulating Bamboo Commercialization, pg. xvi
friendly because it takes bamboo, a resource increasingly needed in its origins of the developing world, and ships it thousands of kilometers away to Europe. Ahrend continues by explaining: “the materials and simple construction of this table fit into the Cradle-to-Cradle philosophy that Ahrend is committed to”. The following citation is from the book *Cradle to Cradle*.

“The idea of local sustainability is not limited to materials, but it is the starting point.”

Even though Ahrend holds several C2C certifications the theory it seems they do not follow up on the same advice when it comes to the bamboo table described above.

One can only wonder what the motive is to become “green” and if in fact it can be called green at all. (See LCA results)

As mentioned above the company does offer some Cradle to Cradle products on the company website:

- A230 Desk Chairs (Silver certificate since JUNE 21, 2010)
- A250 Desk Chairs (Silver certificate since JUNE 21, 2010)
- A500 table line using chipboard or Ciranol (Silver certificate JUNE 04, 2010)
- A500 bench using chipboard or Ciranol (Silver certificate JUNE 04, 2010)

An interesting aspect is the use of Ciranol in the table series, which is C2C certified. According to a Vepa key account manager, volkern the material used (named Ciranol in an article), has no real recyclability characteristics. Why this is possible will be explained in the section about measuring sustainability where the C2C criteria will be observed.

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44 Braungart, M. McDonough, W. Cradle to Cradle, 2007 pg 152
45 Dirk van Ginkel, *Ciranol: a dream material for designers The power of plastic*
These products also have a high level of embedded technology. This is something that also may be perceived as more sustainable, which in John Ehrenfeld’s theory is in fact the cause of the problem in the first place. Adding more complexity may not be the answer (to sustainability), it may in fact be a part of the problem. Although Ahrend does offer wood-based products with FSC and PEFC certifications they also provide none-certified wood for those customers not willing to pay approximately 10% extra.46

Facilities
Ahrend has facilities47 in Eastern Europe and China producing parts. The final assembly is done in the Netherlands. “Alleen de kasten maken we nog helemaal zelf; dat loont namelijk nog steeds.” (Trans: The only thing we fully make in the Netherlands are the cabinets, that still makes economic sense.”)
With respect to waste management collaboration between van Gansewinkel and subsidiary EcoSmart has been initiated to help them reach two main 2020 targets of being “CO2 neutral” and having closed all product lifecycles.

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46 Appendix - 12: Email correspondence with Ahrend employee about PEFC en FSC wood
47 Ahrend verder met de helft, Interview with Theo van der Raadt, Scope Magazine, 31-03-2006
Gispen, like Ahrend and Vepa, also provides a full range of services to their clients. Gispen is a producer of desks, tables, closets, chairs and fauteuils. They, like Ahrend do not deal with a dealer; they themselves are the dealer. To do this they need to collaborate with other companies. To complete a certain look Gispen may offer Herman Miller office chairs for instance, as is the case for the municipal building in the town of Dalfsen. In this way Gispen also acts as their own dealer; that means they need to be able to offer a similar broad line of products that the competing dealers offer.

Gispen has a much broader range of products offered than Ahrend. Gispen offers furniture from many manufacturers including: Aestic, Artifort, Arper, Bomefa, Casala, Castelein, Dutch Originals, Gelderland, Herman Miller, Ineke Hans, Interstuhl, Kusch en Co, Lande, Montis, Moroso, de Raat, Renz, Screen solutions, VDS, Wilkhahn.

NgispeN

NgispeN is Gispen’s answer to Ahrend’s collaborative projects with designers and architects. NgispeN is a product line design by Richard Hutten and other younger designers from the Eindhoven Design Academy. Although focused on the home market in this way Gispen can offer a podium for an artistic interpretation of furniture design.

Gispen and sustainability

In terms of sustainability Gispen seems to be doing what is expected of them. They are holders of the Emas-certificate stating their adherence to an EMS guided by ISO-14000. The only other mentionable step Gispen takes in terms of sustainability is the possibility to refurbish (through repainting) filing cabinets and closets. Steps are also being taken to address the issue of recycling and reusing furniture after they have passed their life expectancy through a possible recall system. Gispen does manufacture in China as well as Culemborg in the Netherlands, this means that they do deal with certain travel distances (and emissions) a company solely producing in the Netherlands does not. Their recent launching of a compostable table top made of bamboo and flax shows they are willing to show their involvement, but it also shows a lack of complete understanding of the subject. Composting a table top in one’s backyard is far from an ideal solution. Incineration or controlled composting would reuse the embodied energy and substances in a more effective manner. In fact, such a method of composting would only add to greenhouse gasses like methane, which is more 20 times better at trapping heat in the atmosphere than CO248.

48 http://www.epa.gov/methane/
Like Royal Ahrend N.V., Aspa, formerly known as Samas, will soon be owned by Stonehaven Holding B.V. that is pending approval from the Dutch anti-trust authorities (NMa) as of the 8th of April 2010. It will merge Ahrend N.V. with Samas (operating in the Netherlands as ASPA). This will make them by far the largest players in Europe with an approximate turnover of 1.5 billion euro’s.

ASPA has been successful in recent years due to a turnaround in company strategy. This success has made it possible for ASPA to acquire a strong position in the office furniture market. With their new strategy, they have positioned themselves as specialists in terms of “Office Identity” and have set their sights on companies who, like them, feel that a distinguishable identity is a precondition to success. Seeing their recent bankruptcy filing this may however be less applicable.

ASPA Office Identity uses Assenburg Office furniture as their main producer of furniture. Assenburg also offers furniture to other dealers though. To supplement their product line they use Samas subsidiaries like Drabert (office chairs) and Sitag.

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49 Press release, HAL Holding 08-4-2010
50 www.aspa.nl
51 www.aspa.nl
52 www.assenburg.nl
53 Appendix 04: Dealer Interview, KMC Office employee
5.2 Benchmarking (Sustainability)

It is clear that companies such as Steelcase Inc., Haworth Inc., Herman Miller, and Interface (not mentioned until now) are definitely in a league of their own when it comes to size and capabilities in terms of creating a “green” image. Although the first three do play a role in the Dutch market Dutch companies have an advantage when doing business in their own country, namely, an inherently more personal approach, not to mention one based on years of experience with the companies.

Herman Miller, Steelcase, and Interface will be used more as a comparison tool than as an actual threat. They are front-runners in terms of having a good sustainable image.

Herman Miller (HM) seems to be highly involved with the Cradle to Cradle brand. They currently hold 8 certificates (6 Silver, 2 Gold) for office chairs alone and hold another 7 for other office related products. The chairs produced by Herman Miller do boast a very high recyclability (Embody Chair: 95% recyclable and made of 42% recycled materials). This is really a big part of the C2C philosophy; making products from recycled materials that cycle after cycle retain their mechanical properties.

However, another part of the C2C philosophy, which does not seem to be as prevalent as of yet is the take-back system. The idea being that a client does not buy a chair but he/she leases a chair, which after a certain time is brought back to the factory to be remade in a new chair befitting of the new demands and wishes of the clients/market.

Revive program

After calling with mymiller.nl (the “official” retailer of Herman Miller chairs in the Netherlands) and receiving a reply the Commercial Environmental Manager of Herman Miller UK it became apparent however, that no large-scale recycling program exists at the moment. Of the 600,000 -700,000 (worldwide) task chairs sold, only around 500 have ever been taken back to Herman Miller under the Revive program. Rather than complete recycling of the product whereby the individual parts are broken done and recycled into granular plastic or other raw materials as is the theoretical basis for C2C, this program refurbishes chairs that have been bought back buy HM. This process seems a bit difficult in terms of defining a value of the product after its first life use. The value depends on the condition, the specification and the age.

Replacing any broken parts and re-spraying the base if needed bring the chairs back

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54 Appendix 07 – Correspondence Herman Miller UK
The chairs will then be sold at reduced prices and with reduced warranties. The Commercial Environmental Manager did explain however that the chairs that were sold “went like hotcakes”.

As far as the recycling plan there is no in-house recycling program however HM has helped Clients to find a local recycling company for the chair. Jackson states: “We believe that recycling should happen as close to the source as possible.” According to his other statements is seems that is what HM is looking to do in the future. It seems that cooperation with waste management companies in this area is inevitable.

One of the points so emphasized in the theory of C2C is its coexistence within the economic workings of society, as we know it. Stating that we not need to make less bad things rather than more good things. The need for sustainable solutions to work next to competing non-sustainable solutions seems to be the main reason why such recycling programs are not working as of yet. Both the (low) price of raw materials as well as the costs behind such recycling systems prohibit such solutions to be economically viable.

**Mentality**

However, to have a vision of the future where furniture will be made more sustainably, one needs to have the right mentality. The following example displays the inventiveness of such a mentality. When confronted with a plague of paper wasps at an HM factory the decision was made to use a certain type of bee (12 beehives, 600,0000 bees) to discourage the unwelcome guests. A secondary and tertiary side effect besides for the primary effect of getting rid of the wasps in an environmentally friendly manner is that honey is produced by the bees that at the same time enrich the surroundings through the cross-pollination of the flowers.

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55 The Strathmore Publication, Herman Miller, pg. 27
in the area. The final benefit is the honey, given away as a gift, as the symbol of their mentality of how to deal with such problems. This is a great example of how sustainability, with a basis of understanding how the environment works, can not only (locally) solve the problem of the wasps, but also create a better environment at the same time.

**Respect for diversity**

In the matter of respect for diversity: a pillar of C2C thinking, one must think of the consequences such a large company has on the diversity of the planet. In the chapter Respect for Diversity a case is made for the use of local materials but also local design to fit the needs of the local market. When Herman Miller develops a chair, they are (more or less) all the same regardless of the final destination. In many aspects this might not matter. After all we all sit in a similar way and we all work in a similar way, but when it comes down to the End-of-Life of a product, for example, each region has their own way of going about the waste management. This has to do with both local habits of recycling (or not) and waste management and the possibilities that even exist to support or hinder any such efforts. Reflecting on the Revive program, which is as of yet only available in the UK it is notable that even there, “it is handled on a case by case basis” due to all of the factors included; i.e: condition, specifications, location, etc. Could this be a sign for things to come when thinking up a viable system for product/material recycling?

**Video Conference**

In order to dramatically reduce air travel, extra video conferencing facilities has been added. This has resulted in a 35% reduction in air travel over the past year.
In the case of Steelcase the difference between image and mentality becomes apparent.
With more than 40 C2C certifications credited to Steelcase and Details (A Steelcase Company), it should be clear that Steelcase has also taken the C2C brand to heart. However, the definition of sustainability given and the proclamation of actually having developed a sustainable chair (although not clear exactly which one) makes their intentions behind their “green” image unsure. The statement on the right is from a brochure about a line of chairs called “Let’s B”.

According to Steelcase, simply basing a product on the LifeCycle Assessment Method is enough to achieve sustainability. Thus, one needs only to “consider potential environmental impact at every stage of the life cycle” to develop a sustainable product. If a comparison is made of different definitions of sustainability then this one is definitely one that does not follow the trend of those stated in the introduction.

An LCA carried out by Steelcase showed that the “Let’s B” chair (not clear which model) was found to have less than 61 kg CO2 eq. Is Steelcase then proclaiming that a chair which has produced 61 kg of CO2 to be sustainable? It is also not clear if this includes the distance to be traveled after manufacturing in Sarrebourg, France (600 km to Utrecht, NL). Since C2C certification does not require any transport impact to be included it is likely not a part of the CO2 footprint.

“Let’s B is a sustainable product because it is based on the Life Cycle Assessment method. That means we have considered its potential environmental impact at every stage of the life cycle, from materials extraction to end-of-use. During our design process, we included both environmental and human health factors in our key decision parameters. Therefore basing a product on the LifeCycle Assessment Method makes it sustainable.”

56 Appendix 10 - Let’s B brochure, Steelcase
57 Appendix 10 - Let’s B Brochure, Steelcase, 2010
Labels
This is a short summary of the material certifications or classifications that are used by Steelcase.
More than 80% of the wood purchased is PEFC certified. All of the chipboard is produced according to the E1 class and 15% of the chipboard is produced according to the E0.5 class. The European Flower Eco-label certifies all of the wool used according to its standards. 75% of the polyester textiles used by Steelcase are according to the Oeko-Tex 100 standard.

Recycling
Steelcase works with van Gansewinkel (specialized in waste disposal) and Ecosmart (specialized in waste management) in the Benelux, which seems to be a local approach when it comes to End-of-Life issues for this multinational. In a similar way they have partnerships in different regions.

Conclusion
It could be argued that judgment on ones words is not an accurate measurement of progress, but rather the deeds should testify one way or the other. However, in this case where the words are meant to promote a culture of sustainable development but rather showcase an inadequate perception of that same concept one is justified to have doubts on their true environmental performance.
The mentality of Steelcase seems therefore to be one of outsourcing. Using C2C is a relatively easy way of creating a “green” image while at the same time taking some of those necessary half-measures (however far they will take us) as noted by John Ehrenfeld. Other labels cover other areas of interest. In this way a number of issues can be handled while not having to devote oneself to a certain mentality.
A company renowned for their sustainable practices and not following the brand of C2C is Interface. This multinational modular carpet and floor system company is a supplier for Vepa. Their philosophy has everything to do with the founder of the company Ray Anderson and his vision on manufacturing and the environment.

**Mentality: Mount Sustainability**

Interface has developed a path to sustainability called “Mount Sustainability”\(^58\). This expanded form of an EMS describes seven (7) “fronts” or steps to overcome to be able to be “sustainable”. These steps are as follows:

1. **Eliminate Waste**: Eliminating all forms of waste in every area of business;
2. **Benign Emissions**: Eliminating toxic substances from products, vehicles and facilities;
3. **Renewable Electricity**: Operating facilities with renewable electricity sources – solar, wind, landfill gas, biomass, geothermal, tidal and low impact/small scale hydroelectric or non-petroleum-based hydrogen;
4. **Closing the Loop**: Redesigning processes and products to close the technical loop using recovered and bio-based materials;
5. **Resource-Efficient Transportation**: Transporting people and products efficiently to reduce waste and emissions;
6. **Sensitizing Stakeholders**: Creating a culture that integrates sustainability principles and improves people’s lives and livelihoods;
7. **Redesign Commerce**: Creating a new business model that demonstrates and supports the value of sustainability-based commerce;

To be able to monitor the progress made on the journey up “Mount Sustainability”,

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www.interfaceglobal.com/Sustainability/Our-Journey/7-Fronts-of-Sustainability.aspx
One of these programs is called “QUEST” (Quality Utilizing Employee Suggestion and Teamwork) and stimulates the employee involvement in the goal to eliminate waste; a step towards the summit of Mount “Sustainability”. Such a scheme represents a voice heard earlier by some stakeholders through the interviews that were held; a voice calling for a “green” mentality throughout all layers of the corporation.

Another program is Missionzero.org. This is an online community initiated to bring those companies, organizations and individuals together who are interested in making a “difference” with respect to (un)sustainability. Interface realizes that interconnectedness is a necessity to becoming sustainable. This reflects a position they hold when looking to nature for inspiration. As stated by the company: one of the principles of Biomimicry (nature as a model for sustainability) is that “Nature rewards cooperation”.

Labels
Interface does not seem to use many eco-labels. Their system of Eometrics™ is the mechanism designed to check and if need be “correct” the path up the metaphorical mountain. It measures the total input of energy and materials and the output of products and waste. The goal is appropriately called Mission Zero™; “…our promise to eliminate any negative impact Interface has on the environment by 2020.”

When compared to the C2C principles many similarities can be found, pointing to perhaps universal rules for sustainable development. Such rules include: using renewable resources for energy. Eliminating the concept of waste; either through re-use of technical materials or the use of bio based materials; the closing the loop concept is practically identical to the C2C principle of the existence of only two material loops (1)Technical and (2)Biological.

Anderson explains in an interview that the company began with tackling the issue of waste (also seen as the first front towards sustainability) as the starting point to save money, which could then be spent on investment in new technologies and R&D.

To bring this vision further than the boardroom and directly on to the work floor employees are encouraged to be involved in a number of ways through various programs.

Programs
Interface has initiated numerous programs for as many aspects of sustainability. They involve schemes on recycling, transportation (various C02 offsetting programs for commercial and private transport), Environmental Product Declarations (EPD’s) with in-depth transparent information of product make-up, energy consumption, employee engagement, bio-based materials (example: PLA) and even biomimicry.

ISO-14000
Besides for a number of Interface facilities that are conform ISO-14000, the EPD’s made are according to the ISO 14042 standard as well.

59 www.interfaceglobal.com/Sustainability/Our-Journey/Vision.aspx
60 www.youtube.com/watch?v=4EsyFUkd75Q&feature=related
61 Appendix 05 – Interview with PET dealer: I
62 Press release Interface: Interface Launches Yearlong Look at Mission Zero™ Metrics, 03-23-2010
LEED (Leadership in Energy and Environmental Design)
From the website64: “Bentley Prince Street’s California mill has become the first carpet manufacturing facility in the country to receive a silver rating from the U.S. Green Building Council’s Leadership in Energy and Environmental Design Green Building Rating System™ for Existing Buildings (LEED®-EB)” Besides this Interface runs a number of other facilities (mainly showrooms) also having various LEED certifications.

Opportunities
A “green” mentality does not seem to be an issue with Interface. After the CEO, Ray Anderson, supposedly “changed the way business was done”, Interface seems to have their sights on a massive target. The sheer number of programs, which they initiated, seems almost unsustainable but with so many facilities worldwide there may be enough room to maneuver and realize their goals to achieve Mission Zero™.

Although Interface is a very different type of business, many things can be learned from their practices. Having them as a partner should be seen as an asset and according to Interface corporate policy cooperation with Vepa would be encouraged.

64 www.interfaceglobal.com/Sustainability/Sustainability-in-Action.aspx
6. Conclusions

The Vepa mind-set for well-founded scientifically based insight into the complex domain of sustainable development whereby caution is taken not to run head first into anything that sounds green is a testament to their down-to-earth mentality. The complex nature of sustainable development requires a well-balanced approach. They are a company willing to invest in those first steps which can put them on the road to sustainability. The company’s in-house manufacturing of tabletops, for example, allows them to more easily certify the (shorter than some competitors) chain of custody. This control gives them some freedom and ease others dealing with longer chains of custody may not have.

These first steps include the use of wood-based paneling (engraved in company heritage) for furniture. Now that the company is moving towards E0 particle board and already supply only PEFC and FSC wood out-of-pocket, they have made clear steps in verifiable environmentally better options when it comes to the development of furniture.

In terms of the measurable environmental impact as seen through the LCA the material (choice and use) and end-of-life stage are the determining factors for chairs and in general more compact products. Besides these two factors, transport to the client also plays a larger role for more bulky products. Significant improvement in these areas would result in significant improvements in the total environmental impact.

In terms of sustainability one could say that the products are within the guidelines of sustainable furniture as set by the Theory of Eco-Cost/Value Ratio. The reliability of this argument is however dependent on a number of issues. One being the assumptions that must made to define a sustainable environmental impact, the other is the reference to the standard which needs to be improved upon.

In terms of product sales, clients remain hesitant when it comes to wood-based cabinets. The preference seems to be with steel cabinets, although the reasons are unclear. Vepa continues to struggle selling the idea of wood-based cabinets despite their clear environmental advantages when compared to their steel counterparts. Both the eco-costs, and the ReCiPe points as well as the Carbon footprint are about half when compared to using steel in a similar case. Of all Vepa products, when compared to the competition, it is the cabinet K-Store and thus arguably the entire wood-based cabinet lines that have a significantly lower environmental impact than that of the competing steel cabinet lines. Any improvement in market share in terms of a shift from steel to wooden cabinets would result in a more significant improvement in overall environmental impact, than a marginal improvement on self-produced chairs and tables.

Although there is a demand for C2C and other standards for sustainability the dealers and or account managers are usually able to discredit those arguments or convince the clients for other solutions which may not have the same “high” standards but also does not include the same price connected to names such as Herman Miller. However, some support to help Vepa clients to think about environmental issues would be appreciated.

In terms of external companies going “green”, a segmentation could be made. On the one hand with companies genuinely seeking for better solutions and using that (rightly so) as a marketing feature. (Something also taught in the Natural Step) And on the other hand as some may call “green washing” whereby the solutions may even apply for eco-labels but do not show an approach to sustainable development throughout the corporate structure. It must be said here that these insights are mainly gained through online research of corporate websites, which is always the

65 Appendix 02 - Interview Key Account manager
66 http://www.naturalstep.org
image a company wants to portray, not who they in fact are. Even so it is therefore the more revealing when a company aims to inform the reader about aspects of sustainability but rather misinforms them instead (see Steelcase example in external analysis). It is therefore paramount for any company wanting to be involved in sustainable development to understand the science and complex nature of such a subject.

An important factor in Cradle-to-Cradle theory although not included in Cradle-to-Cradle criteria for a certification is the factor of transportation\(^\text{67}\). The most C2C labels seem to be owned by the multinationals (i.e: Herman Miller, Steelcase, Ahrend, etc.) producing and selling all across the world with transportation possibly having a large influence on the environmental impact.

This is where Vepa has a positive starting point with their relative locally produced and consumed goods. The shorter chain of custody also cuts down on the steps of transportation a material, component, or complete product must follow. This, along with the use of wood-based paneling, is a strong point in terms of sustainability and should be focused on in terms of marketing of Vepa and sustainability.

In general Vepa has a number of strengths which should be used appropriately to maximize any opportunities available.

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\(^{67}\) A quote from the book *Cradle to Cradle*: “The idea of local sustainability is not limited to materials, but it is the starting point.” Explains the sustainability benefits of locally acquired materials.

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**SWOT analysis**

On the next page a SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is shown. This is a summary of conclusions stemming from the internal and external analysis. Influential factors included here will help give a direction for the development for more promising solutions.
6.1 SWOT

**Strengths**

- Flexible to change, due to size and structure and corporate mentality
- Good control over most of the processes that occur throughout product development
- Production with wood as strong sustainable foundation
- “Local” supply (Europe) and demand (Benelux)
- Good reputation with dealers for wood-based furniture.

**Weaknesses**

- If compared to their rivals Vepa will have more difficulty in pushing a leading “green” image
- No real power towards large suppliers. Any influence goes slowly
- Dealers (and Key Account managers) are unaware of sustainability issues of Vepa or specific knowledge of sustainability (see opportunities)
- Sustainable “mentality” is not prevalent throughout company

**Opportunities**

- Companies interested in “Green” solutions: Essent, Achmea, RaboBank, the Emmen Zoo
- Regulations are broad and excludes many issues
- Clients are un- or ill-informed

**Threats**

- High competition for price
- Competition for green “leader” in sector
- Regulations are broad and excludes many issues
- Sustainable solutions have reputation of being more expensive
- Difficulty in selling “idea” of wooden cabinets in office environment

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6.2 Focus points

**Focus points**

- Not dependant upon third party; make use of short chain of custody
- The foundation (material choice) has been laid.
- Making use of local resources (preferably in-house “waste”; very small closed loop)
- Possibilities to use this reputation.
- Use wood-based cabinets as foundation of green image.
- Come up with own solution; don’t expect upstream solutions,
- Show difference between steel and wood options.
- Opportunity to explain to clients how wood based cabinets “fits” in the environment.
- Show that the choice for wood does not follow this dogma.
- Come up with own innovative solution: using opportunities in wooden paneling.
6.3 Direction

To demonstrate the guidelines for sustainable development, by means of an example which can be used for future development, a product category should be chosen. A choice must be made between cabinets with a significant environmental advantage when compared to steel competitors or improving similarly scoring tables and chairs.

The former will have a more significant impact on the environment because of the difference between the two options. A significant improvement of “environmental friendliness” would need to be made with the analyzed chairs.Crudely said, selling just one more wooden cabinet in place of a steel version results in approximately 4 ReCiPe points less damage to the environment. This is approximately the equivalent of a 33% reduction (1 point) to 4 chairs sold. To put this into perspective the ratio of cabinet and chair sales are circa 1:1.5 to 1:2. The dilemma then arises between selling twice as many “33% better” chairs when compared to selling one more wooden cabinet (acquiring more market share). A similar argument is applicable to the table line where comparable figures play a role.

With less investment needed in production facilities at the plant and more investment on selling the idea of a green alternative to steel-based cabinets, the direction to focus on cabinets and wood-based furniture seems to have more potential in the short term.

Why stimulation of wood-based cabinets:
- Selling one more wood cabinet versus a steel cabinet results in 3-5 ReCiPe pts less in overall terms. (“When buying a cabinet, the choice for Vepa is better for the environment.”)
- This is equivalent of selling 3-5 chairs with a 33% (1 pt.) decrease in ReCiPe points a piece.
- Potential to show, by example, what sustainability is about: the use of Particle board: a renewable “waste” material, in furniture.
- Seemingly less potential for improvement due to high particle board influence on overall impact: if it can be done here, than good example for other product lines)
- Vepa has major control over production.
- Any improvement made here could be translated to other product lines using particle board. or in general terms to other product lines.
Vepa - An Exploration Towards Sustainability

synthesis phase
Vepa - An Exploration Towards Sustainability

Synthesis Phase

Daan Lans

in cooperation with Vepa Office Furniture in Hoogeveen,
the Netherlands

Graduation committee

Chair: Prof. dr. ir. Han Brezet
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Company mentor: Ir. Wilbrand Menzo

Delft University of Technology
February 2011
Synthesis: Summary

LCA-based office furniture development

The analysis phase gave direction on what it is to be environmentally friendly and sustainable. In this section this gained knowledge is used to develop a wood-based storage unit for the office environment. Through the use of eco-label and eco-design guidelines, LCA-based environmental impact and sustainability indicators like Eco-costs, the Eco-cost to Value Ratio (EVR) and ReCiPe points, a boundary and baseline for new product development can be set. From this “baseline” any improvement in the environmental impact can be measured.

In addition to this the LCA based indicators are used to help in the development of the new product. They help identify key impact factors like material use and transport volume on which to focus further development. The use of modularity and the (re)consideration of primary functions of a product can be promising starting points. Furthermore, “Streamlined” LCA’s can be executed to support in decision making steps throughout the design process.

As shown in the report, it is possible to develop an environmentally friendlier particleboard-based office storage unit using current technologies. Minimal adaptation is needed. Changing the product structure and using the materials, by far the most influential environmental impact factor, more efficiently can result in a significant improvement. Improvement in Eco-costs and ReCiPe pts. of 20% are achievable. Carbon Footprint and Cumulative Energy Demand are lowered even further due to the proportion of this energy intensive material which is used.

Before eco-effectiveness is economically viable in all sectors, eco-efficient design can help in making office furniture more environmentally friendly and maybe even sustainable.

- The S-Store prototype in Hoogeveen
7. Introduction

Which steps need to be taken to become a manufacturer of sustainable office furniture and what does this mean specifically in the cases analyzed above. To get anywhere, a map showing the route to where to go is usually very useful. However, when dealing with unknown territory no maps are available. In this case a clear goal must be formed so that all involved can head together in the right direction. By understanding the final goal a route can be traced backwards from that goal. This process is called “backcasting” and is a method to connect a present situation to a desired set of conditions set in the future. It is a key part of the process taught by The Natural Step (TNS) and used by Interface and others in their processes towards sustainable (product) development (although TNS involvement is not mentioned in the analysis, in the case of Interface the result is “Mount Sustainability”).

In the first chapter of this second part these (future) conditions shall be put forward. After which a route will be explained. To start off on this route a product will be developed using the guidelines set up to support a more sustainable process for development.

As stated in the previous section the focus for the second section will be on the use of wood-based materials for office furniture.

Problem definition

Vepa would like to show their intentions in terms of sustainability to their clients. The solution should show, using a broad scientific basis, its extent of sustainability. A comparison with Cradle-to Cradle (and other) guidelines can be used to put both the proposed solution and certification systems in perspective to their clients, dealers, and internal employees. In this way a broader more independent (of C2C or other eco-labels) understanding of sustainable development can be realized and what Vepa is doing in terms of them.

The use of particle board is shown in this report, but also through research outsourced by Vepa to be “better” for the environment than the choice for steel for a similar application. Despite this, according to Vepa, wooden cabinets remain less popular in the office environment.

What are the reasons for this and how can Vepa stimulate the acceptance of wood-based cabinets in the office environments?

Below the original assignment definition as stated in the first section:

Trigger: Vepa has limited specific knowledge of the environmental impact and thus the sustainability of their products and can therefore only take general steps to strengthen their position in a market increasingly influenced by a demand for sustainable solutions.

Assignment: Analyze relevant products’ environmental impact to identify possibilities for Vepa and make a (re)design of a product befitting of the goals set by the company so as to create an example for other products to follow.

Results: Product (re)design as a showcase for the company environmental goals.

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68 www.naturalstep.org/backcasting
69 The natural step is a program set up to help companies use sustainability as a market potential instead of a threat. Its core feature is making sustainability work in the business place. Their approach is used by a number of companies like: Interface and IKEA.
70 Presentation IVAM: LCA screening kantoormeubelen: CO2 voetafdruk en milieueffect
8. Design Direction

Setting the boundary

Which conditions would allow the manufacturing of (office) furniture to be a part of a sustainable world? To which guidelines must the development of furniture adhere to be able to support a more environmentally friendly way of production. Since the border area of sustainability is too vague to say with any certainty (the discussion about improvement factors 4, 10, 20) truly sustainable system can only be guaranteed when more than is strictly necessary is done. Therefore the next question arises. “What does it mean to do more than is strictly necessary?”

What is sustainability?

“The possibility for all life to live indefinitely on the earth.”

Since a manufacturer only has direct control over their own actions a company cannot be expected to change the world on their own. In this case a company/individual should do what is within their power71.

The following are aspects which can be influenced by the manufacturer:

- Material choice (origin, quality, environmental en physical characteristics)
- Material quantity
- Process choice (gluing, welding, snap connections)
- Process quantity (process follows design)
- Energy choice (non-renewable, renewable)
- Energy quantity
- Transport choice (non-renewable, renewable, compactness of shipped goods)
- Transport quantity

As stated before, a goal must be developed which states the final point for what is to be regarded as being a sustainable situation.

Below are eight (8) points to help in lowering the impact to the environment:

- Maximize the use of (local) renewable resources72.
- Use recyclable resources sparingly, make use of recycled materials.73
- Minimize processing of high-impact materials (e.g. Chipping of wood is better than steel).74
- Help extend product lifespan75.
- Complete product transparency: know exactly what each product contains.76
- Have a plan for the End-of-Life phase of the product which includes facilitation in closing the material cycles.77
- Minimize transportation impact.
- Minimize energy use.78

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71 Some companies and/or organizations do take part in certain programs or include certain steps for sustainability which also include informing others of sustainable development (e.g. Interface’s Steps 6 and 7 of “Mount Sustainability”: Sensitive Stakeholders and Redesign Commerce) or a collective good like the “1% For The Planet” program from Patagonia clothing store founder Yvon Chouinard.

72 Quote from UNEP Sustainable procurement guidelines for office furniture: “Finally, it is also important to highlight that timber is a renewable resource in comparison to other materials such as metal or plastic. As such, its use in furniture should be promoted... Furthermore metals are not renewable. Therefore, in general terms, in order to reduce the environmental impacts of metals, the most straightforward criteria would be to reduce the amount of metals used in favour of wood (based) materials.”

73 Blaue Engel, C2C, and Nordic Swan eco-labels all establish this fact as a basic DfS principle.

74 The impact of waste during production is normally taken into account: this makes the dilemma interesting between two amounts of different waste. One could choose for more waste with a lower impact material if that is in total less of an impact than a small amount of waste of a high impact material.


76 All Eco-labels require the knowledge of product’s contents. This describes the origin, and end-of-life possibilities.

77 C2C is maybe the most obvious follower of this rule, however understanding the entire product lifecycle is important to all sustainability guidelines.

78 Eco-labels: Blaue Engel and Nordic Swan have energy content limits.
The separation of technical and biological cycles is not mentioned above for the reason that is a criteria which is partially at odds with the use of particle board as a more environmentally friendly solution than steel for the same purpose. Although the melamine or laminate, containing phenol and other petroleum-based resins are considered technical nutrients their combination with particle board (also containing both technical and biological materials) does show to have a lower environmental damage than the powder coated steel alternative.

Because the particle board solution, for the solution analyzed, has a total lower LCA outcome it can be argued that the separation of material streams does not necessarily mean that a solution is more environmentally friendly. The C2C criteria therefore functions as a guideline to help in the quest and are thus not a rule. When corresponding with EPEA\textsuperscript{79} about this dilemma it was stated that the LCA approach is a problem based analysis and not used within the C2C approach\textsuperscript{80}.

However, since the LCA method is the only real way of knowing the emissions and influences a solution has on the environment it is the results of the cabinets where it can be seen that the first steps have already been taken by Vepa in the choice to focus on the use of wood-based paneling for the manufacturing of cabinets and other storage products.

The following steps should be taken to further lower the environmental burden of this product.

These guidelines are based on the insights gained through the LCA (quantitative and qualitative), and the different certification criteria (mainly qualitative) researched in the analysis phase.

The LCA points out that most of the impact is caused by the choice and amount of material needed and the possible end-of-life scenario it follows. These, along with the extension of the product life as a precursor to making all products better for the environment, will be the three main focus points in terms of environmental sustainability.

To test the improvement in terms of sustainability the new product(s) should adhere to a list of criteria compiled as the definition for a more environmentally friendly solution. This list is also combined in the design criteria list in Appendix 17.

\textsuperscript{79} Environmental Protection and Encouragement Agency (EPEA), Founded by Michael Braungart and offers certification services for Cradle to Cradle applicants. (www.epea.de)

\textsuperscript{80} Appendix 12 - Email correspondence with EPEA
Below are a set of general factors which in the case of Vepa Office Furniture are relevant in the development of environmentally “friendly” products. These factors are divided into the different criteria which comprise them. Results from the LCA show certain aspects where the eco-labels show other relevant aspects. On the next page these general criteria are specifically addressed to the Vepa solutions offered. To the left are two Design for Sustainability (D4S) Strategy Wheels. On these wheels the different focus areas for sustainable development are displayed. The top wheel shows the focus points when looking at the impact assessment (LCA), while the bottom wheel displays the drivers’ focus points. These drivers are the forces acting on the company to become “green”. These forces are the dealers (and clients) asking for sustainable solutions, and have their origins in systems offering solutions to more environmentally friendly development like Cradle-to-Cradle and (other) eco-labels. The next page specifically shows these focus points in terms of the Vepa product characteristics.
9. First Step Towards Sustainability:

Problematic areas for sustainable development

- Use of standard energy supply
- Glue foam to wood
- Use of PUR foam
- Material transparency of stacker
- Glue steel to aluminium
- Use of chrome VI
- Material transparency

- Material choice: Steel, Aluminium
- Material use
- Distance of end-user
- Production waste separation: Currently ~5 streams
- PVC (with softeners)
- HPL and particle board
- Chrome
- Glue foam to wood
- Gluing of steel and aluminium
- Materials used not always clear
- Use of “standard” energy supplier
- Accreditation as proof
- Differentiation in terms of DIS
- Teach dealers about DIS
- Make sustainability transparent
- PVC with softeners (weekmaker)
- HPL and particle board
- Only Chrome III
- Limit on Chrome and Nickel emissions
- Foam Blowing agents
- Gluing of steel and aluminium
- Materials used not always clear
- High material use
- High transport impact to end user
- Use of standard energy supply
- Use of PVC
- Use of chrome (VI)
- Material transparency

Problems
9.1 Design Objective

In the case of this project the focus will be on the wood-based cabinet because of its undervalued “good” environmental attributes and its ability to display the Vepa goals for sustainable development.

Design objective:
Design wood-based product, with the K-store cabinet as inspiration, to demonstrate environmental performance of wood-based furniture and showcase Vepa sustainable development goals.

Within the design objective three main goals can be identified:
1. Improve on product further to apply to standards for sustainable development.
2. Demonstrate environmental performance of product.
3. Promotion of wood-based furniture.

These three goals will now be explored individually to be integrated at the final stages of development.

1. “Improvement” on product; environmental and functional
What to improve on is determined by the comparison of the product with the criteria for sustainable development and the focus areas chosen based to the drivers as shown on page 69 with the D4S Sustainability wheels.

2. Demonstrate environmental performance of product.
To make the environmental performance clear to the public an understandable way of providing such information should be given.

3. Promote wood-based furniture.
To promote wood-based furniture in general a starting point for improvement could be the reasons for unpopularity. To understand what the main reasons are for its reputation(s) a small investigation took place. Below the main reasons are given:
Reasons for unpopularity:
• Negative opinion on quality (i.e. through association to “flat-pack” products.)
• Higher price than steel alternative
• Traditional mind-set (expectations of what an office interior should look like)

81 Appendix 15 - Research into unpopularity of Wood-based products.
9.2 User research

The following insights were gained through observation and interviews of office employees using closets and other storage units.82

Since the stored documentation (contracts, regulations, notes, minutes, drawings) varies widely the cabinets allow for such flexibility; (shelves for books or folders, racks with hanging (project) folders, (loose) paper trays).

The use of wood and wood-based units has their pros and cons. A negative aspect of wood-based products is the (perceived) weight. They are also thought to be more susceptible to damage and that when damage has occurred it is more obvious then when compared to steel.

Tambour (jaloëzie) doors are quite often left open for the ease of not having to open and close the doors. Units with tambour doors need to be fully open to be able to retract sliding folder organizer.

Wood, however, is preferred to be on the countertops because of its beneficial thermal properties. Therefore medium- and low-level cabinets are usually fitted with an additional top of melamine or laminated particleboard or solid phenol core (thick HPL).

Below are some steel based cabinets with sliding doors. These work secondarily as a room divider between the different workstations. Half is used while the other half is inaccessible, as can be seen here.

The use of a door is an interesting element in the possible solution to a closet. A door is a secondary function of the product and its main purpose is sometimes unclear. Common arguments for the need of a door - or any other solution that creates a barrier between the content and the context – are security from theft, avoidance of dust, and a clean and orderly look.

In many cases doors seem to be open throughout the day. They are sometimes closed during breaks and usually during off-hours.

It is too much of a burden to continually open and close the storage unit doors through out the day. Therefore many doors are left open during working hours. This is especially the case with tambour doors, being slightly more of a burden to open and especially to close than pivoting doors. This can be seen as an advantage in terms of keeping doors closed. Tambour doors are more of a burden when closed and are thus left open when not being accessed. Whereas a pivoting door is more of a burden when open and is thus closed when not being accessed.

Since this functionality is apparently not always necessary and that both closets with and without doors function primarily the same way doors should be used when this is absolutely necessary.

82 Appendix 15 - Cabinet Use Research

Two very different office interiors in Rotterdam.
9.3 Design Criteria

This design project involves the development of a more environmentally friendly K-Store bookcase. The new product should show the way towards such development in the future and be able to compete with the current solution. Vepa would like a new product because:

- It wants to know how to deal with the problem of product sustainability.
- It wants to show its commitment towards sustainability.
- It wants to have a bigger share of the market.

With the goal being the development of a K-Store inspired storage unit with better sustainability characteristics a number of criteria are set up to guide the process. The full list of criteria can be found in Appendix 17. The process tree of the development of a closet is also present in the appendix. From this the criteria for sustainability during design and manufacturing and for use and disposal are extracted.

The working criteria used throughout the design process are:

- Use processes close to Vepa.
- Reduce material use where possible.
- 4 meters of shelf space
- Possibility for hanging folder drawer (380mm wide and 380mm deep)
- Enough height for A4 binders and hands (350mm)
- Vepa quality standard should be maintained.
- Materials can be separated into clean material streams.
- The materials should come from an as close as possible supplier.
- The product should work in a first (initial buyer) and second life (second-hand buyer/user).
- Stay within price range of K-Store. (See internal calculation sheet not included for confidentiality reasons.)
9.4 Process

By using the LCA method in the design process, the relevant impact factors are found. In the case of the office furniture analyzed the most influential factors are materials, end-of-life (mainly influenced by materials) and also transport in the case of the closet.

Priorities can be set according to the relative influence of each factor. In this case it can be seen as a “regular” design criteria with a weighted factor. It can be weighted more or less depending on the development philosophy of the company; e.g. is it worth changing our company style for? On the other hand, it may also be seen as a stand-alone criterion, which is compared to a “baseline”, the product one chooses to make the improvement on or compare the new design with. This is more of a standard D4S approach.

In this process both are used in parallel. By doing this an attempt has been made to try to weave sustainability thinking into the standard design process, as well as using the D4S principles whereby a clear goal through the referencing (benchmarking) of another product can help in creating a better product.

Relevancy of design through benchmarking

To start the process, the baseline is set to have a reference to the outside world.

In this case the chosen baseline is the K-Store basic closet. A “Fasttrack” LCA calculation of this closet with doors was done in the analysis phase of the project.

Developing a baseline product makes it possible to compare, on as equal terms as possible, the difference between the original and novel solutions. The “stripping down” of the original K-Store to only a bare closet with 3 additional shelves, creates a minimal boundary for the new solution to fit into. The margin for error decreases as the overall weight decreases (i.e. each component plays a larger role within the whole). Therefore, if a reduction in the environmental impact can be achieved in such a case, then a similar approach would most likely result in a reduction with other product variations. As the list of criteria changed however, so does the FU. Trying to keep the two solutions as comparable as possible requires multiple adaptations to the LCA calculation throughout the process.

The functional unit (FU) in design

To be able to develop an alternative which is comparably better, a functional unit needs to be determined. Both the old and new designs need to fulfill the same functionalities and it is in terms of these functionalities that the comparison must
be made. One does not describe the closet as what it is (i.e: cabinet for books) but rather by what it does (i.e. stores 4 meters of books, folders, etc.)

It is preferred that a comparison is done with as much information as possible. This would result in a more complete comparison. However, since not everything is known about the product from the onset it is advisable to repeat the calculations as progress is made in the development. The LCAs are obviously the most important during moments of decisions. Depending on the developer’s Design for Sustainability Vision different choices can be made if the LCA does not clearly identify a better solution. What is clear or not depends on the situation. If the situation is complete and all of the consequences are known then any percent reduction or improvement in the environmental impact can be seen as an adequate figure. However, if the situation is unclear (early stages in the process) and the consequences of the choice have not been completely identified then even a difference with a factor of 10 may not be enough of a margin to fully justify a choice. Each situation is unique and should therefore be approached and judged separately with as much information as possible. One can only judge completely if all of the information is known, whereby significant improvements in one area may already have been watered down by some sacrifices in another. An example is the integration of functionalities within (one piece of) a material. The final processing may be more but the initial gain through material reduction is substantial enough to compensate for the extra processing. When a manufacturer would choose to use only renewable energy sources to power their processes an extra impact reduction can be made. This does however depend on the process and processed materials. Powder coating would become significantly better since a large amount of energy is needed purely for heating the ovens, but extra chipping of high-scoring materials whereby the waste material is counted could result in proportionally less improvement.

However, the functional unit is ideally a comparison tool between two (2) solutions that offer the same functionality. To reiterate: lowering the complexity of the product and thereby making the description as fine as possible will help in setting up the FU more clearly.

In the case of the development of the S-Store some of these functionalities have changed in number (e.g. S-Store can also more easily be used as a room divider) or in composition (different style; different market; different price). It is therefore more difficult to make a fair comparison due to the changing of the functional unit. Although both can be judged on the original FU the S-Store may have more functionality. Ideally its impact should therefore also be divided over that extra-added functionality, thus diluting it and therefore resulting in a lower impact for the original functional unit.

**Design dependent and design independent sustainability improvement**

The issue of sustainability can be tackled in a number of ways. The design of the product obviously has a great deal of influence on its environmental-friendliness. However, other factors can also have a large influence. As can be seen in the Roadmap a number of these design independent steps are explained. One discussed more deeply here is the impact reduction due to material choice.

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83 For example, the choice between steel or a common polymer, like PS, for a certain application can really only be made if the design and the processes governing its existence and disposal are known. By only looking at the eco-scores of the certain materials one cannot make a sound decision. If the steel application needs less surface area to obtain the same functionality as that of its plastic counterpart and therefore minimizes the amount of powder coating needed and no recycling possibilities exist for the PS version, then it may be conceivable that the steel object has a lower overall impact than that of the plastic one.
Material-choice based impact reduction

The material (choice and use), for instance, has the biggest influence in the total environmental impact of the product. A number of materials fit for Vepa’s production facilities are discussed in Appendix 18: Material choice. By simply choosing such materials a reduction in the total material impact by even 16% can be achieved. Just choosing a different material can thus already have a substantial influence. However, in this case only the origin of the material is changed and the design of the product is left unchanged. This is possible because the materials behave nearly identically. This is relevant because it shows a way to incrementally improve the product with the smallest amount of effort. (Vepa is continuously looking into new materials, their properties and how they can be marketed.) This is a relatively easy approach to reducing the impact. Changing the design so that it actually needs less material to function is a better solution because then a compounding effect is possible. Both material choice and use are then improved.

### Alternative 1

**Surface finish**
Paperstone Melamine (no-change)

Core
Petro-free HPL which uses post consumer recycled paper for substrate. Only available in North America.

(www.paperstoneproducts.com)

### Alternative 2

**Surface finish**
Melamine (no-change)

Core
No change, however the LCA shows this application as having the lowest impact when compared to the alternatives.

### Alternative 3

**Surface finish**
Flaxboard

Core
Natural beech veneer has very low impact. The finish needed makes it higher in total.

Natural oils like Linseed, Walnut (Europe) and Tung (China) are good surface treatments with no VOCs.

(www.environbiocomposites.com)

### Core

- **Paperstone**
  - Eco-board is produced from the waste of the agricultural industry (ie; wheat, etc.)
  - MDI is used as the bonder and produces no formaldehyde emissions. Production in Europe is set to begin in under a year.
  - Current European supply comes from Malaysia.
  - (www.eco-board.eu)
  - Other suppliers (US): (www.environbiocomposites.com)
  - **Advantage:**
    - Makes use of agricultural “waste”.
    - No formaldehyde (emissions).
  - **Disadvantage:**
    - Impact of MDI is not clearly known.
    - Available LCA data is questionable.

- **Eco-board**
  - Flaxboard is made from as the name gives away, flax. Flax is a rapidly renewable resource with a major producing region being Northern France, Belgium and the Netherlands. The panels are E1 certified.
  - (www.linopan.com)
  - **Advantage:**
    - Lower density results in less weight
    - This has limited benefits in transport impact.
    - Flax is “locally” produced and is also used in the production of linseeds and linseed oil (natural varnish).
  - **Disadvantage:**
    - The binder is urea-formaldehyde based.
    - Lower density can result in limited physical characteristics.

- **Soy-based adhesive Purebond**
  - Soy is a renewable resource (low impact)
  - Early stage of development. Becomes competition in agriculture and raises demand, thus raising prices for soy-based food.

- **Various material alternatives which could be used. (See also Appendix 18: Material choice.)**
Design based impact reduction

When the material (choice) is mostly predetermined, as is the case of the S-Store, efficient use of materials becomes even more important. How can one obtain the same functionality from less material?
The choice for a modular design is something often referenced to. Not only do the TU Delft/UNEP Design for Sustainability Guidebook and the Designer’s Field Guide to Sustainability allude to modularity in design, it was also an outcome in the first creative session as a way to make a product better to repair and be more flexible in the way it offers its functionalities.

Here are some of the advantages to modular design:

1. Flexible in use - Different set-ups for different uses can be realized.
2. Easy to repair - If a module is damaged it can be repaired without having to repair or replace the entire product.
3. Transport reduction - Since the product can be assembled at the location transport volume can be reduced; further lowering the environmental impact.
4. Logistics - Creating some standard sizes increases efficiency and ease in production and decreases internal storage capacity and transport impact and costs.
5. Smaller is stronger: The smaller (module) size would also result in a relatively stronger unit. It is for this reason that some material reduction can be achieved.

10 The starting point: Modularity is the key

Various sources pointing towards modularity as a possible solution field.
10.1 Conceptual design

Many different shapes in panel-form (represented by cardboard) were explored to find new ways of building a closet in a modular way. Different ways for stacking, connecting and assembling were looked at. Each alternative was closely examined and judged on the grounds of material reduction, transport volume, ease modular connection, multi-functionality and visual impact.

The ideas which seemed to have the most potential in terms of material and transport reduction (the most important factors) were selected and further developed into concepts.
10.2 Concept development and choice

Four concepts were developed which in different manners all try to increase material efficiency (in general through working with smaller structures) and reduce transport volume (in general by fitting into each other). The concepts aim to increase the strength of the individual modules by making every connection rigid. They also fit into each other so as to reduce the volume needed during the transport.

These four concepts are explained below:

**H-Store**
- Stacks by gravity and form locks into place.
- Conservative look; simple but elegant
- ca. 40% reduction in transport volume
- Raised shelf stiffens structure so as to provide “room” for material reduction.
- Each module is independent of the rest.
- Can be built into a high or low structure.
**S-store**

- **Use of material**
  - Particle board (12mm should suffice due to the smaller distance between the exterior walls and center column.)
- **Multi-functional**
  - Storage
  - Information wall
  - Perpendicular, Anti-vertical处处
- **Transportation**
  - Slanted walls ensure less space during transportation.
  - Save up to 60% of transportation volume.

**C-store**

- **Connect in 4 steps**
- **Connecting**
  - Uses weight of shelf and contents to tighten levels together.
  - The heavier the load, the tighter the connection.
- **Transportation**
  - Slanted walls ensure less space during transportation.
  - Save up to 50% of transportation volume.

**B-store**

- **Use of material**
  - Particle board
- **Customize**
  - Stackable
  - Adjustable height
- **Can encircle an area**
  - When grouped the backs form a circle-like enclosure.
- **Connection**
  - Form fits into itself
  - Clips on side to be used for other applications elsewhere.
  - See general technical details for information on attaching units together. The units are stackable and in this way many variations are possible.
- **Transportation**
  - Slanted walls ensure less space during transportation.
  - Save up to 60% of transportation volume.

**C-store**

- **Use of material**
  - Particle board
- **Customize**
  - 2 sizes (small, bigger)
    - H: 40cm, D: 40cm, W: 35 cm or 45cm
  - 2 sided use
- **Multi-functional**
  - Storage
  - Information wall (A3 horizontal, A4 vertical)
- **Transportation**
  - Saves almost 50% of transportation volume.

**B-store**

- **Use of material**
  - Particle board
- **Customize**
  - Stackable
  - Adjusted height
- **Can encircle an area**
  - When grouped the backs form a circle-like enclosure.
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- **Connection**
  - Form fits into itself
  - Clips on side to be used for other applications elsewhere.
  - See general technical details for information on attaching units together. The units are stackable and in this way many variations are possible.
- **Transportation**
  - Slanted walls ensure less space during transportation.
  - Save up to 60% of transportation volume.

- **Can use 12mm board on the sides**
- **60% reduction in transport volume.**
- **Can fit half-full folders more efficiently.**
- **Connected using clips.**
- **Can encircle an area when placed next to each other.**

**C-store**

- **Use of material**
  - Particle board
- **Customize**
  - 2 sizes (small, bigger)
    - H: 40cm, D: 40cm, W: 35 cm or 45cm
  - 2 sided use
- **Multi-functional**
  - Storage
  - Information wall (A3 horizontal, A4 vertical)
- **Transportation**
  - Saves almost 50% of transportation volume.

**B-store**

- **Use of material**
  - Particle board
- **Customize**
  - Stackable
  - Adjusted height
- **Can encircle an area**
  - When grouped the backs form a circle-like enclosure.
- **Connection**
  - Form fits into itself
  - Clips on side to be used for other applications elsewhere.
  - See general technical details for information on attaching units together. The units are stackable and in this way many variations are possible.
- **Transportation**
  - Slanted walls ensure less space during transportation.
  - Save up to 60% of transportation volume.

- **Can use 12mm board on the sides**
- **60% reduction in transport volume.**
- **Can fit half-full folders more efficiently.**
- **Connected using clips.**
- **Can encircle an area when placed next to each other.**

**C-store**

- **Use of material**
  - Particle board
- **Customize**
  - 2 sizes (small, bigger)
    - H: 40cm, D: 40cm, W: 35 cm or 45cm
  - 2 sided use
- **Multi-functional**
  - Storage
  - Information wall (A3 horizontal, A4 vertical)
- **Transportation**
  - Saves almost 50% of transportation volume.

**B-store**

- **Use of material**
  - Particle board
- **Customize**
  - Stackable
  - Adjusted height
- **Can encircle an area**
  - When grouped the backs form a circle-like enclosure.
- **Connection**
  - Form fits into itself
  - Clips on side to be used for other applications elsewhere.
  - See general technical details for information on attaching units together. The units are stackable and in this way many variations are possible.
- **Transportation**
  - Slanted walls ensure less space during transportation.
  - Save up to 60% of transportation volume.

- **Can use 12mm board on the sides**
- **60% reduction in transport volume.**
- **Can fit half-full folders more efficiently.**
- **Connected using clips.**
- **Can encircle an area when placed next to each other.**
### C-Store

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### Melamine

#### [C-Store]

**Scenario 1**

Incorporation and max recycling

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#### [H-Store]

**Scenario 1**

Incorporation and max recycling

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### Additional Notes

- Here are four (4) LCA's of the closets. But in fact only two aspects are being looked at. The relative difference is also taken into account. They are streamlined because all other factors are kept the same.
- Doing this gives an actual LCA based weighting to the criteria. It is not subjective, because it becomes clear (keeping some margin in mind) which factor is more important and by how much. As more variables become known the true picture becomes clearer.
- Being able to use 12mm PB would result in significant reductions. The H-Store would have the biggest reduction where the C-Store the least. The H-Store may not be entirely made of 12mm. (above is with only 12mm) Therefore a smaller reduction is used during the judging of the concepts.
- Although this is very tedious work, it does give a realistic feel for the improvement. One must be careful though not to see too much in the figures. Small differences here can be misleading.
6. User flexibility: To what extent is the use flexible?
7. Transportability: Is the module easy/difficult to transport?
8. Vepa image: To what extent does such a product fit into the Vepa style? Image, construction, etc.

Based on this set of criteria a selection was made to continue development on.

As can be seen in the matrix; the C-store scores quite low on a number of criteria. This is mainly due to its inherently weaker structure. This has a number of effects which in turn makes it score lower with a number of other criteria. The C-Store should therefore only be seen as an example of how the context can help in the design.

By adding extra material with a third column, strength should be added throughout the design, whereby 12mm board may be used. In terms of material reduction potential (see LCA) user flexibility, and overall strength of the design the S-Store has the most potential to be developed further. The H-Store may not be as strong as intended and furthermore offers less flexibility for the user. The same is the case for the Bee-Store.
11 Embodiment design

The evaluation of the concepts pointed quite clearly to the S-Store as having the most potential for further development. The embodiment design phase includes a number of aspects to be looked into. The following aspects of the closet will be discussed below:

1. Overall size, and structure
2. The base unit
3. “Doors”
4. Intermodular connections.
5. Material choice
6. Processing

Even though this is an orderly list of the developed aspects of the closet, the actual development happened mainly parallel and with multiple iterations. This is due to the fact that all aspects are interrelated to each other and thus have a cause effect relationship. This is always the case in a design process, in this case however, any differences are looked at more specifically by using the LCA method. This where the “streamlined” LCA's are used. Since many aspects stay they can be left out, leaving only the differences between the concepts to be measured. This has been done to help in the decision making process, on issues like the base unit, and the doors. These aspects and the final results will be explained in the paragraphs below.

Where the LCA's cannot work or where there is no significant difference choices still need to be made. Throughout the development of these aspects a number of criteria are considered. They are weighed to their relative importance and used to judge the proposed solutions for each aspect. Although the some criteria differed for each of the aspects, three main criteria were constant during all decisions.
These criteria are:

1. Quality: How is the quality of the solution?
2. Eco-impact: What is the relative eco-impact when compared to the other proposed solutions for that aspect? Also considering its affects on different aspects.
3. Modularity consistency: To what extent was the modularity of the concept being compromised with the proposed solution? I.e.: creating too many variations would make the final solution too complicated to take advantage of the modular build-up.

11.1 Module size/shape

In theory the size of the closet should be determined by the contents inside and the functionality given to it. The comparison with a beehive structure and nature’s use of materials in the most efficient way possible whereby an optimum between two conflicting interests is made:

1. Volume enclosures vs. use of area (whereby the rectangle is the most efficient shape.)
2. Material use vs. volume enclosure (whereby the cylinder is the optimal shape) 
3. Minimum of material usage when both area and space enclosure are both optimized.

The same should be said for the size of the individual modules comprising the whole. The height for the module should be dependent on the contents to be put into them. In the case of a stand-alone unit the height for the hanging folders should therefore not be the same height as a module to be used for A4 binders or other materials ranging in the A4 (290mm) to A4 binder range (320mm). The
hanging folders need in general to be no more than 250 mm (210mm for a landscape oriented A4) including some extra height and width to compensate for the hanging folder and the roller system normally used for this application (380x380mm). It is therefore unnecessary to make this module much higher or even the same height as the other modules. However, to increase the flexibility of the modules and the modular system itself it is necessary for the modules to have the same border properties, i.e; the height and width and method of connection should be identical for the modules. In this way any module can be connected to any other module. Regular storage compartments should be fit for A4 binders and the like. Although many A4 binders include a hole to pull on, it is not a certainty; therefore extra room for a hand (±36mm\textsuperscript{84}) should be taken into account to assist in pulling out such a binder. This results in a module inside height of just under 350 mm.

However, in the development of this storage system whereby multiple units can be placed next to or on top of each other independently (i.e. any module can be placed anywhere) the module boundaries need to be identical to connect to each other. This counts for stacking the modules at the location, but this also counts for the stacking of the modules during storage and transport. For this reason the depth of the modules would, ideally also be 350mm. In this way the modules fit perfectly into each other with minimal (12mm board thickness) overhang. However, due to the restrictions of the drawer mechanism the depth is limited to 380mm. Again, maximizing the used material.

\textsuperscript{84} 310 mm for binder + 36 mm for P95 of dutch citizens aged 31-60, source: www.dined.nl
Mechanical testing

To get an idea of what the limits are for particleboard a FEM (Finite Element Method) analysis tool is used. The effects of changing the architecture of a closet in such a way that essentially the shelf is clamped on 3 sides as opposed to being supported on the two ends can be simulated. In this way it may be possible to predict the amount of particleboard or any other material for that matter, which is minimally needed.

For a fair comparison a FEM analysis is first done on an 18mm shelf with the dimensions of 764mm by 382 (the inside width and depth of the K-Store closet). A roller support is not possible with Simulation Xpress and therefore a rigid fixture has to be used. The shelf can contain eleven (11) A4 binders. A full binder weighs approximately three (3) kilograms and is about 72mm wide. A shelf full of A4 binders would therefore need to support at least 33 kilograms. The following simulation was done with a load of almost 500 newton distributed evenly over the shelf. This is approximately 1.5 times (margin) the expected combined weight of the binders. Because the material, in this case particleboard, is a composite material it will not act like an isotropic material whereby it is homogeneous and the forces work linearly in it. Nevertheless, the material properties supplied by the Cambridge Engineering Selector (CES Edupack 2010) was used to define a new material in Simulation Xpress. Using the “regular” shelf as a control would in theory neglect any adverse effects between the two set-ups (unless the displacement is extreme).

This setup is repeated with two “new” shelves of different lengths. Each represent the longest span in the module being tested. The wider the module can be the more material can be spared. Therefore both 900 mm wide module and a 1000 mm module are tested. The widest spans in the 900 mm module is 508 mm and respectively 608 mm. These will be loaded according to the same standards as the control; fully loaded with 3kg weighing A4 folders plus 1.5 times margin.
Results

The result is a vertical displacement of 1.5mm in the middle of the control shelf. When a comparable amount of force (7 binders totaling in 21 kilograms x 1.5 times margin over the distance of 508mm) is applied to a thinner and “smaller” shelf supported on three sides, the displacement is actually less. In this case the displacement is 0.9mm.

For the span of 608mm a displacement similar to the “regular” shelf is seen. Here the shelf also sags about 1.5mm.

Real life testing quickly shows a slightly different picture. With about 20 kg the shelf (608mm) is displaced by about 2 mm.
Design for flexibility or design for specificity

When the modules are placed in an office their orientation is often in a way that two sides touch each other. This does not seem to be an efficient use of materials. However, when looking to solve such a dilemma the other sustainable attributes should not be lost. Since the product will most likely last longer than its buyer intends to use it for, a second life should be made possible. It is preferred to develop a product which keeps this in mind. (see also pg. 108) By making a product only work within a certain situation will render it useless when placed elsewhere.

Like the IKEA “Stockholm” closet line, so do the drawings and prototypes shown here “solve” this problem of the double wall. However, in the case of a move, whereby the closets may get a different orientation and not all can be placed next to each other. In this case the solutions is very rigid and not open for change through out its life style. This is the case for all of the solutions shown here. To maintain a high level of flexibility it may be more responsible to not minimize the solution too much.
Conclusions

Since the stress tests seem to end in comparable results it can be assumed that the shelves will be able to carry the full load of the binders despite its thinner construction. Real life testing is however the only way to see if the thinner panel is up to the task at hand. Even though the displacement is minor, the nonlinear mechanical properties of the particleboard are difficult to simulate in this way. Real world testing, as shown above, gives quick insight to shorten the span and thus choosing for the 900mm module length. Still an arbitrary number, since it could be argued that a truly sustainable design should be void of such standardized sizing. Would it be more important to develop cabinets based on the standard sizes, or which way it most efficiently uses the materials it is comprised of? In practice however, standardization does increase efficiency and ease for the builders and users. The top left shows the design submitted for prototyping. This demonstrated a problem during production, namely the necessity to turn the middle panel to drill two sets of holes. This can be avoided by shortening the middle panel and extending both front and rear panels to cover the middle panel. This has the consequence, however, that the doors for an “M” module and an “S” module are no longer identical, thus creating more parts. As progress is made, and more insight is gained, changes made to improve one aspect have consequences for another. This needs to be looked at carefully during further development. More parts also makes the assembly more complicated. Although the processing may be quicker, if mistakes are made and parts need to be discarded than with respect to sustainability it would be advisable to keep the part count down and the module simpler and thereby accepting the increased manual labour and accompanying price. However, if this is not likely then the extra overall gain for the design change is therefore justified.

- Due to difficulty during production, middle panel needs to be turned to drill both sides correctly. Adapting the module to the configuration below solves this problem.

- However, this does create a problem with the doors if the opening is on one side. The opening changes whereby different doors are needed for an M-Module than when compared to an S-Module. A choice would need to be made between more steps during production or more parts.
11.2 Base Unit

Since the closet is now built up of three (3) vertical columns of 12mm distributing the weight downwards instead of two 18mm thick columns this force must also be carried over to the floor on which it stands. The base is the unit that transfers these forces from the modules above to the floor.

Three concepts were discussed. The decision criteria matrix was more or less disregarded on the grounds that an entire new module as the base unit would solve many of the issues. The consensus was that it would be stronger, transfer the weight of the upper modules better and have a better aesthetic quality due to not seeing the adjustable feet.

Through this dialogue with the fabricators and others the first modules were made with a separate base unit/module. The sides would extend downward, through which the majority of the forces would flow and be transferred to the adjustable feet attached to the inside of the sides.

### Base unit choice

<table>
<thead>
<tr>
<th>Base unit choice</th>
<th>C1 Quality (Stability)</th>
<th>C2 Eco-impact</th>
<th>C4 Transport Volume</th>
<th>C4 Lifespan</th>
<th>C5 Modulariteit</th>
<th>C6 Transportability</th>
<th>C7 Vepa image</th>
<th>Σ(λ jej)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base unit 1 - Particle board open</td>
<td>5</td>
<td>125</td>
<td>6</td>
<td>150</td>
<td>5</td>
<td>75</td>
<td>6</td>
<td>90</td>
</tr>
<tr>
<td>Base unit 2 - Particle board closed</td>
<td>8</td>
<td>200</td>
<td>8</td>
<td>200</td>
<td>7</td>
<td>105</td>
<td>6</td>
<td>90</td>
</tr>
</tbody>
</table>
After the first base module was made, however, it became apparent that the extra support was indeed needed. The design was adapted there and a permanent toe kick was added. The forces are now also partially transferred to the toe-kick beam and outwards towards the sides and to the adjustable feet. This adaptation results in a change in the adjustability of the feet.

Since the feet are located under the bottom shelf a hole is needed, like in the K-Store now, to be able to adjust the height of the feet. The proposed feet are available from a local Dutch supplier who also provide the current feet for the K-Store.
11.3 Document protection, product transparency and door types

To shield off a closet’s contents can have various reasons and levels. Some of the reasons are perhaps for dust or to create the appearance of a clean office, others may even be for security reasons. The concept offered here already takes into account the “need” for a clean office look. Only half of the contents of the closet are visible at any time. The closets create the illusion of a cleaner office environment due to the splitting of the front and backs. In essence it is as if half of the doors of regular closets are closed.

With office closet doors in many cases being left open during the day, protection from dust or theft from employees (75% of employees in the U.S. have committed theft from their employer85) cannot be offered.

Despite many closets remaining unlocked (due to missing keys etc.) or even open, the demand for a (lockable) door should be considered and a solution should therefore be available. But to which criteria should such a solution adhere? If a thief wants to break into a closet he/she will. Therefore there is a limit to how theft proof a closet can be. The closet should therefore connote the same idea of protection as the K-Store.

To ensure that a material is being used to its fullest extent it may be necessary to force the user to handle in a certain way. It are the tambour doors which are more usually left open. In this way the choice for a “traditional” pivoting door can be justified on the terms of dust accumulation and the “clean office policy”. The more hours the doors are open the more dust that is likely to settle in the cabinets. Keeping the doors closed therefore could result in cleaner closets and a more tidy office look. Moreover, less material is needed than when using tambour doors, which make the closet wider, deeper, and usually have a double wall to prevent content from coming into contact with the doors.

According to some sustainability findings and general trends, product transparency is an attribute to be taken into account. The workings of a tambour door are not clearly seen (through double walls) and the working of a pivoting door communicates more of a simple message through the reduction of complexity.

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85 How to Prevent Office Theft, Jenna M. Aker, Buildings, April 2009
A few concepts for doors were explored and judged using similar discriminating criteria as before. Since materials (particleboard as the baseline with the K-Store) is again the most determining factor in the LCA, a number of different options were looked at as starting points:
1. PMMA (Acrylic) (4mm)
2. Glass (4mm)
3. Melamine particleboard (12mm)
4. MDF (Mainly looked at because of its ability to have an integrated handle)
5. HPL (Full core) (Not considered due to pre-existing knowledge about its high environmental impact from the analysis phase)

Even though less material may be needed for a glass or acrylic door, the eco-impacts a partial LCA shows differences between the materials of a factor to 2 to 10. Since there is little difference in the types of hinges and “knobs” available and the processes needed to apply the different materials, particleboard was chosen as the main constituent of the door. Integrating a handle folded in PMMA or glass is apparently not enough to offset the significantly higher impact of the material choice. Besides this, processing of such higher impact materials has an adverse effect on the environmental impact.

Key here is to not forget aspects. Adding edge banding to the PB door is a necessary step to make this door function like the others. This needs to be taken into account in the LCA. In principle such an LCA is not correct because it does not represent the complete LCA. However, knowledge of the processes involved help in understanding their significance. Since cutting, for example, is needed for all materials, such impacts will only be larger with higher impact materials, like, glass, and PMMA. With this knowledge it can be said with high confidence that the PB solution will have the lowest overall impact. Such an LCA is also called “Streamlined LCA”, whereby only factors which are different between the compared solutions are analyzed.
Door type, hinge, doorknob, doorstop are all linked together and the choice for one influences the possibility for another. Some concepts were developed and are shown below.

At the time of writing this product development was at a crossroads. Based on a number of criteria like: quality, eco-impact, lifespan, and modularity the choice was made to incorporate inlay doors using a pivot hinge. This was based on a low eco-impact due to an extremely simple construction, easy assembly and adjustability of the hinge. Additionally, a spring-actioned doorstopper and the inlay doors function as a “doorknob”. Since the entire door is the “knob” it is of no consequence on how high or low the module is.

After studying the prototype (100cm) it became apparent that inlay doors might not be the best choice. Due to the fact that all particle board shelves sag (over time) and that the inlay doors can only have a few millimeters around them to minimize see-through, the sagging of the shelves would be visible next to the straight edge of the door, and may even result in rubbing or jamming of the door in the module. Although this does have the preference (see choice matrix below) and a module of 900mm wide does seem to sag significantly less at its broadest point this can only be finalized by testing during further development.

A second option is therefore also shown. The overlay doors hide and avoid any problems caused by possible sagging.

A rendering of the model is shown here. The overlay doors with smaller hinges are more typically seen in caravans. This is because the “regular” hinges (with cup sizes 12-13mm) are suitable for “regular” doors with a thickness of 16mm or more.

It would be preferred that the hinges were used with an even simpler layout, however, this smaller type of spring-loaded hinge also allows for the door system to

<table>
<thead>
<tr>
<th>Door choice</th>
<th>C1 Quality</th>
<th>C2 Eco-impact</th>
<th>C4 Price</th>
<th>C5 Lifespan</th>
<th>C6 Modulariteit</th>
<th>C7 Transportability</th>
<th>C8 Vepa image</th>
<th>Σ</th>
<th>Σλjejij</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door 1 overlayed 1 (full core)</td>
<td>5</td>
<td>125</td>
<td>5</td>
<td>75</td>
<td>6</td>
<td>90</td>
<td>7</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Door 2 overlayed 2 (cup)</td>
<td>7</td>
<td>175</td>
<td>6</td>
<td>90</td>
<td>6</td>
<td>90</td>
<td>7</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>Door 3 inlayed 1 (pivot hinge)</td>
<td>5</td>
<td>125</td>
<td>8</td>
<td>120</td>
<td>5</td>
<td>75</td>
<td>4</td>
<td>7</td>
<td>35</td>
</tr>
</tbody>
</table>
be totally independent of the modules around it (a negative aspect of the pivot hinge solution mentioned above which would have been solved by drilling two extra holes in the bottom of the shelf of each module) while allowing for more adjustment possibilities than the pivot hinge.

Since there is no need for a spring-actioned door catch now that the frame stops the door a doorknob is needed. Simple testing showed that it is possible to pull open the door without a knob or handle. However, this, like all choices made above must be true for all possible types of modules and their relative positioning. The arrangement can arise whereby two (or more) modules with openings on one side are stacked with doors in both modules. In this case it is no longer possible to open the door by simply pulling on the side. There is insufficient room (ca. 4mm) between the doors. A doorknob is therefore necessary. Integrating a doorknob into the door could be the most ideal solution, however not technically possible in (12mm) particleboard. The following solution is proposed on the grounds of having the lowest eco-impact, a fair quality, fitting character and excellent end-of-life (e-o-l) attributes. Steel, aluminum or polymers need to be recycled at the e-o-l and only steel and aluminum will most likely be recycled to a high standard. Unfortunately, this is the most realistic scenario as it is unlikely anyone will take the time to remove a steel or aluminum door handle. And even being separated in the processing plant may not. Since biopolymers are harder to come by, are more energy intensive and would be burned anyway the choice of a carbon “neutral” material like wood is not only less harmful to the environment, but also more easily available in the (traditional) market place of furniture accessories. With low initial material impact, (final knob can be smaller than pictured here; this is an existing knob offered on the market) low processing impact and great incineration properties, wood is definitely the best choice here.
Unfortunately time is limited because ideally other systems could be used to keep the documents protected from its environment. Although many ideas like these shown here were developed, more time is needed to see if such ideas are feasible. The essence of these ideas and of true sustainable development is function integration. One knob works in keeping its door and the adjacent door (100cm wide unit had 2 doors) closed while at the same time offering the lock the ability to do its job. The essence is that a door with a lock would look different than a closet with only a door. Each solution adapts uniquely to the specific problem at hand. Nothing is independent. Each piece works together with another to fulfill the total function required.
11.4 Intermodular connections

**Vertical connections**

To complete the strengthening of the modules they should be connected to each other. To maximize the strength of the total closet the connections should be made in both the vertical and horizontal directions.

The vertical connection prohibits the upper corners from straining when stressed. The initial connection is made with a connecting bolt between the upper and lower module. This is a fragile connector when not in use but is preferably installed at the manufacturing facility in Hoogeveen to reduce build-up time on sight. The use of cardboard sandwich panels should constrain the bolts sufficiently during transport.

**Horizontal connections**

Time constraints have not allowed any further exploration in this topic other than the use of the same technique that is currently in use by Vepa to connect adjacent closets. Finding a solid anchor point for the connector is key here. The modules are stronger at the bottom where the sides make a wood-to-wood dowel and glue connection with the bottom shelf. Since it is not known what type of module it will be connected to the hole should be placed in such a way that mirroring the modules will have no effect on the alignment of the connector holes.

In terms of aesthetics the horizontal connections are ideally made at the point where the vertical connection is also made. In this way no hole would be visible on the sides of the modules and the connection are then independent to which modules are (not) placed adjacently. This is more important for the second life of the product whereby a different orientation of the modules may be requested. Ideally no damage is visible from its past life; i.e. holes on the sides for adjacent connections.
11.5 Processing

Although no real values are known about the definitive processing, the S-Store seems promising when compared to the K-Store. Since the most significant impact factors are known through the Baseline LCA executed at the beginning of the project, an estimation can be made according to the changes in the processes. The most significant processes and their changes are explained below.

Weeke

Despite the S-Store having more parts in total; 6 panels per module x 4.44 modules (with 4.44 modules the same amount of book space, FU, is achieved) resulting in roughly 27 (smaller) panels per 4 meters of book space. This is 3 times more than for the K-Store. However, in the case of the K-Store, the Weeke, the machine with the highest environmental impact in the factory and the most influential in the LCA calculation due to its maximum power output (accounts for nearly half of the processing impact86 and its operating time of 11.5 minutes. During these 11.5 minutes it mainly drills the holes for the shelf holders and dowels. In the two (2) side panels a hole is drilled every 32 mm apart nearly the entire length of the closet. With two (2) rows per side this totals to about 240 holes to be drilled. This count excludes any holes for the toe-kick, top and bottom panels.

The S-Store, although comprised of more panels, needs about 100 holes to be drilled in total. This includes 22 holes per module for dowel connections and connectors between the modules for 4.44 modules, whereby 4.44 modules gives the equivalent of 4 meters of storage space.

The result is expected to be a lower machine time (about half), but more labour time. This would result in a lower environmental impact and if the extra price can be represented in a higher value then this would in turn lower the EVR in a well-

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86 See Appendix 08 - Vepa product sustainability: An LCA on a selection of Vepa products
intended way (lowering eco-impact and increasing value).

Because of this the LCA calculation shows an identical running time of the Weeke.

**Edge banding**

Unfortunately, the layout and design of the S-Store makes it need more edge banding. The total amount of edge banding needed for the K-Store is approximately 20 meters. This includes the shelves. The S-Store needs about 7.5 meters per module resulting in a total length of about 33 meters assuming 4.44 modules is the equivalent FU (functional unit).

Although the total amount is less (see Appendix 18: Material choice) due to the choice of PP (lower density) and a thinner version, the length is nevertheless increased by 1.6 times. Since the running time is proportional to the length (assuming same speed of edge banding and excluding start up time), this proportionally increases the edge banding process time by the same amount. In the case of the S-Store with doors, the increase is by a factor of almost 2.3.

**Press**

Although more than one unit can fit in the press at one time. The impact of the pressing of the units is multiplied by 4 because doing so is unlikely.

**Waste**

In terms of waste it is also difficult to tell how much more or less is left unused. The K-Store calculations are done using a waste factor of fourteen (14) percent. In other words, 14% material is assumed lost. Fourteen percent of a PB sheet of 2.44m x 1.22 m is equivalent to a stroke of ca. 35cm wide and 1.22m long. No such stroke is seen here. This seems very promising in terms of waste reduction. In the LCA calculation waste numbers are kept constant. Both the K-store and the S-store are calculated with a 14% loss of material.
11.6 Prototype

As can be seen here the prototype is working as expected. With all the connections fitting, the modules become surprisingly strong and stable units. At the time of writing this report a second model was under construction. This model is meant for aesthetics and should represent the product in which it is intended. (see Appendix 25: Color Exploration S-Store.)

- The first humble modules; to see if 12mm would work. If it is possible with hand tools it is possible with the craftsmen at Vepa.

- Structural prototype of S-Store using 100 centimeter wide modules.
At first sight everything seems to be alright. Testing the limits of the material however does case the 100 cm module to sag 3mm in the middle of the 600mm suspension.

The model with two side-by-side base units with on top of that 4 modules. This is a height of approximately 1.2 meters; a comfortable height to be used as a room divider adding an extra level would create a little more privacy. Removing a level of modules would also decrease some privacy.

Some faults arise, luckily due to a machine inaccuracy and not due to the design. The design’s “S”-shape, however, does prohibit the sides to be pressed together, a consequence of the composition accepted earlier on the development phase. Pressing the panels together would remove any gaps like this which is less than one (1) mm wide.
11.7 Final product

- An office environment using the S-Store.
Modules and some possible configurations

- Base module with inlay door
- Base module with one side half open: "S"-shape
- Base module with one side fully open: "M"-shape

- Base module and "regular" S-module with inlay door
- Base module and "regular" S-module
- Base module and "M"-module

For color justification see Appendix 25: Color exploration S-Store
12. Design Impact

To test the final design a “Fasttrack” LCA can be completed again. Although it is already known that the new design will have a total reduction. The exact amount is not known. This is because the perspective is lost when looking at a certain level of the product. Also, throughout the process margins for error were used because of unknown factors. These margins can now be reduced to a more accurate level. Now that enough information is known (product details are known) about the product a final analysis can be executed.

Total environmental impact in 4 indicators

Just as during the analysis phase the LCA is executed in 4 indicators. The differences in reductions shall be explained here.

The closets without doors show a greatly significant difference between the two. This is a direct result of being able to do the same thing (FU) with 48 kilograms of particleboard instead of the regular 68 kilograms. This 30% reduction in weight accounts for the entire reduction in material impact. Other materials, like the extra edge banding (still a smaller net amount than the K-Store, but a similar impact), steel, and the zinc-aluminum connectors add to the impact. Since the use of the other materials is also as minimal as possible their negative influence (mainly due to their higher eco-scores) on the total impact is minor.

Materials

With material choice already largely predetermined it is the use of it which has been changed. The structure is smaller and with more box-constructions similarly as strong.

| Material Impact of K-store (gray) and S-Store (green) without doors. |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Eco-cost(€) | ReCiPe(pt.) | CF(kgCO2) | CED(MJ) |
| 11.09 | 8.36 | 4.65 | 11.09 | -25% |
| 51.05 | 36.80 | 2603 | 1867 | -28% |

| Material Impact of K-store (gray) and S-Store (green) with doors. |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Eco-cost(€) | ReCiPe(pt.) | CF(kgCO2) | CED(MJ) |
| 11.83 | 10.77 | 5.79 | 53.71 | -28% |
| 2686 | 2296 | -15% | -15% | -15% |
CED and CF value

The CED and CF values decrease more, proportionally, than that of the single indicators like Eco-cost and ReCiPe. This is because PB is a material with higher energy values and the CED and CF are directly related to the amount of energy used and how it is sourced. The Eco-costs and ReCiPe points take more factors into account and are thus forced to weigh one factor with another depending on their relative importance. A measurement which is already higher in the case of using PB. It is for this reason that the CF and CED cannot necessarily be used to determine the environmental impact of PB. Using more energy does not make it worse.

For many substances the CF and CED values do correlate significantly with other impact indicators like ReCiPe points and thus give a balanced view of the environmental impact (Huijbregts et al., 2005) (Huijbregts et al., 2010). As stated in these studies, particleboard along with other agricultural and forestry related materials do not necessarily follow this trend. In the case of such materials the energy used during processing is often non-fossil based (often biomass), thus creating inconsistent environmental impact data in terms of global warming and land use when such energy would, for example, be based on fossil fuels. In other cases the use of fossil energies (along with other factors) and its link to among others, global warming correlate more significantly with other environmental impact indicators. Unfortunately this is not the case for particle board, further illustrating the complexity of environmental burden quantification, and the care one needs to take when determining the impact to the environment with a single “issue” indicator. The single issue in the case is global warming.

(Non-measurable) Knock-on effects

Having less/different materials in a product has many knock-on effects. These are discussed in the appropriate sections.

Processes

The same is true for processing, however, the knock-on effects are now negative. Choosing for extra connectors also bring with them more processes and transport. These parts, after all need also to be made. Fortunately, these will be significantly less due to their proportionate size. This is even more so the case for the S-Store with added doors. (Below)
Transport

The final volume reduction is estimated to be at around 48%. Packing material between the modules like blankets and cardboard sandwich sheets will increase the volume a bit (about 40 mm per 2 modules).

There is an extra added benefit however, the weight reduction will also reduce the transport further. (see Knock-on effects above)

- Transport impact of K-store (gray)
- Transport impact of S-Store (green) with doors.
- Transport impact of K-store (gray)
- Transport impact of S-Store (green) without doors.

The graphs are of the total transport impact. The reduction is therefore a sum of both the reductions on materials coming to Vepa (measured in kg) and leaving Vepa (measured in m³) as the final product.

The final transport volume is calculated to be just above half (52%) of the original volume of the K-Store. This is due to the extra space needed for a cardboard sandwich panel to cover and protect the screws during transport. (If the screws cannot be inserted on location). Using the mechanical lamello would be a great advantage here.
End-of-life

In terms of the end-of-life, the choice was made to design for the “real-world”. Many products are branded as being recyclable (see Darwin Chair pg. 112) but are never really able to be recycled. Such is the case with edge banding. Edge banding is glued to the particleboard. Although one could say that this is still recyclable, it will most likely not be recycled. It will follow the path of whatever material it is attached to. In this case it is particleboard. Its incineration is therefore a burning of fossil fuels (PP being derived from petroleum). This is why a biopolymer, like PLA, would be a better choice (see appendix 18 - Material choice).

Because of the above mentioned fact and due to the slow movement in the market. (Even Herman Miller barely takes back any office chairs.87) The best end-of-life solution for the product is incineration. If the product can no longer fulfill its function, the most environmentally friendly choice in the short to middle terms is to “win” back as much energy as possible from the products’ materials. Since about 90% of the weight of the product is due to the use of particle board, an energy intensive material, it would be the best environmental choice to incinerate the material and win back some energy needed to produce it in the first place. In this way the gases can be filtered as much as possible in contrast to letting a material decompose (Gispen flaxboard panel). Decomposition emits the CO2, and methane (25 times more powerful greenhouse gas than CO2) and loses the energy put into it. The downside to combustion is the extra transport needed. In the case of combustion this is 40 km to an AVI88. The LCA dataset Idemat2010 already contains the transport impact factor for end of life.

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87 Appendix 07: Email correspondence with Herman Miller Commercial Environmental Manager
88 Distance used by CE in Delft according to MERLAP, 2002
Total impact

As can be seen here the new design decreases the environmental impact significantly, depending on the configuration. These are the two extremes: One set-up where no doors are used (above) and another set-up whereby all open spaces are closed off with a door (below).

Much of the impact reduction gained in the closet with no doors is lost in the closet with only doors. If this a case of two extremes than the truth will lay somewhere in between.
13. Conclusion:

13.1 Product

As has been demonstrated here, it is possible to develop an environmentally friendlier wood-based closet using the techniques of now. No investment in new technologies is needed. Changing the product structure and using the materials, the most influential environmental impact factor, more efficiently can result in a significant improvement.

Extra added environmental benefits such as damage control, and user flexibility may not be measurable, but would only add to the impact reduction.

Fundamentally, it is important to ask oneself if he/she really needs these functionalities in the proposed solution. Functionalities not used are a waste of resources and could be applied more effectively elsewhere.

In this way truly sustainable product development can be compared to nature and the steps evolution takes to better adapt plants and animals to their environments. A plant or animal evolves in a way that it can ensure its (genes') existence by efficiently making use of all available resources, how meager they may be. These evolutionary adaptations (e.g. camel's hump to store energy in the form of fat for when food is scarce) is a testament to such processes. Truly sustainable product design thus evolves over time to best adapt to changing conditions (flexibility to different demands). Unfortunately materials and products still have limits in their ability to be flexible for different uses. Therefore the composition of these materials should be in such a way to evoke different uses over time. When the demand changes the product can then also changed to meet the demand.

The choice for the original baseline K-Store without doors on the grounds that a “stripped” down closet would have less margin for error and thus more difficult to improve on has not been proved nor disproved. Therefore a conclusion is that with any design process but especially with design for sustainability getting the list of criteria specific enough is crucial.

Furthermore, the contrary of the presumption may actually have been the case. By “stripping down” the closet to its bare elements the functionalities may have been simplified in such a way whereby abundant room for design change resulted in an unexpectedly high environmental impact reduction. Even when adding many (simple) doors the solution still results in a net reduction in terms of environmental impact.

The strength of this concept is that any amount of doors can now be added and its impact reduction (when compared to the baseline) will be somewhere in between the 21 and 5% (eco-costs) range.

If the initial criteria included the use of some type of document protection the resulting concepts would most likely have looked very different. If all content needs to be secure, it would not seem sustainable to use so many hinges.

**Design objective:**

Within the design objective three main goals were be identified:

1. Improve on product further to apply to standards for sustainable development.
2. Demonstrate environmental performance of product.
3. Promotion of wood-based furniture.

By tackling the main issues the product's environmental impact has been reduced considerably. This can be seen in the outcome of the final the LCA. Furthermore, the new functionalities can help in the promotion of panel based furniture.
13.2 Sustainable or not?

The conclusion of the analysis phase ended with the remark about striving for eco-effective solutions, whereby there is basically no impact\(^8\) to the environment. In hind-sight eco-efficiency is not only more realistic, but also more relevant. With constant population growth and two huge booming economies, demand for materials (renewable, recyclable, non recyclable) will only become greater, further driving up prices. To have knowledge about the development of products using as little material as necessary to fulfill the needed functions will become an asset in the future where materials will become scarcer every decade.

\(^8\) Many companies claim they want to be CO2 neutral or have no emissions. Even Interface has their program called: MissionZero. This usually only counts for CO2 emissions and therefore disregards the bigger picture of materials scarcity, species extinction, etc.

13.2 Summary of the process

The development of a new product on the basis of LCA calculations gives confidence in steps taken. However, one should not rely too much on the model, because it is just that, a model. It can be very easy to forget certain aspects when looking at alternatives. Caution is therefore advised. The better the information is; the better the reliability of the outcome of the LCA.

After a vision for (sustainable) product development has been set up by the company certain goals can be set. (Example: reduce Eco-costs of certain product line by 10% in 2 years.)

To make a reduction possible a benchmark must be set. This is done by selecting a representative product of that certain product line. Depending on the vision one
could choose a product with relatively high expectations so as to raise the bar for future development. Any reduction here could already be seen as an achievement. Obviously raising your to more than 10% is also an option. The TU Delft D4S guidebook (Crul and Diehl, 2009) does suggest however not to set the goal too high for the first project. If it would fail for some reason the motivation for future projects may be dampened.

The defining of the FU. Keeping this more simple, but as concise as possible, will increase the ease during the development. To which terms should the old and new products be compared. (4 meters of folder shelves or 4 meters of folder shelves with the possibility of changing shelf height and closing the contents off from the environment) Perhaps, this also requires the reconsideration of certain functionalities.

Having defined the FU the benchmark can be made by means of the Fastrack LCA. During the LCA calculation it should be clear what the boundaries are for analysis. The comparison should be done on as equal terms as possible and the boundary of the LCA should reflect this. With this comes the E-o-L scenarios. Keeping these realistic as possible is most likely better than developing products made of materials that might possibly be able to be recycled. Depending on the expectations for that material/process a realistic e-o-l scenario would be advisable (e.g. incineration of particle board door incl. edge band and door knob)

Locate the major impact factors. Within the furniture sector, material is most likely the most influential factor (electric furniture excluded).

How can these materials be reduced or replaced by less high impact materials? Ways of reducing materials can be found through:

• the use of modularity
• the integration of functions
• the reconsideration of functions
• a connection with the context

Other impact factors can be looked at in a similar way.

Both within the old and new solutions a “streamlined” LCA could be executed to achieve marginal gain when using a different material within an existing solution (Design dependent and design independent sustainability improvement see pg.74)

The edge banding is an example of this.

The completeness of this LCA like any LCA is crucial: The comparison can therefor seldom be made on material alone. Which processes are involved in making the material usable for the solution (e.g. cutting, welding, powder coating of steel vs. extrusion molding of plastic.)

During the LCAs it is always good to include some margin for error. In this way one can be sure that the new solution is definitely better during the execution of the final LCA.

Execute a final LCA of the new solution and compare this to the benchmark, Does it score better? Where should more improvement be made to achieve the goal. The process, like product development is never ending. Once goals have been achieved, new goals have already taken their place. The process continues.
13.3 Design Dilemma’s: When theory meets practice.

“Scorability”

Some issues cannot be scored with the LCA method. These issues usually pertain to added value of the product, like design for disassembly. The possibility to disassemble a product may allow it to take less space during transport however; Vepa has shown that disassembly is not always the most efficient way of loading a delivery truck. It disallowed for stackability in some cases and thus actually took up more room. Some aspects which decrease the environmental impact but are not directly measurable are discussed below. The S-Store is compared to other examples on these issues.

Quality

Quality is also such an issue. A product of quality should last longer and thus may be allowed to have a higher impact score than that of a product of lesser quality, which would be expected to last less long. How can one measure the quality and guarantee a longer lifespan and thus a lower impact when compared to that of an object with lower life expectancy? The score and lifespan should be proportional with a certain factor.

Like in the EVR such standards could be set up according to a certain environmental impact indicator like CO2 emissions, whereby a product/service is “allowed” to have a certain eco-score (or ReCiPe pts.)

This is where the EVR (or any coupling with the economy) has an advantage. This coupling grasps the bigger question: Is the environmental impact sustainable or not?

The following is an example of why:

*Design problem: Shelving unit fit for 4 meters of books not to exceed 2 meters in height.*

<table>
<thead>
<tr>
<th>Solution</th>
<th>Material</th>
<th>Detailing in Design</th>
<th>Lifespan</th>
<th>Price</th>
<th>Eco-score (“allow-able”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Thin fiberboard / Cardboard</td>
<td>Rough</td>
<td>1-2</td>
<td>90</td>
<td>3-5</td>
</tr>
<tr>
<td>2</td>
<td>Particle board</td>
<td>Medium</td>
<td>10-20</td>
<td>900</td>
<td>6-10</td>
</tr>
<tr>
<td>3</td>
<td>Hardwoods</td>
<td>Fine</td>
<td>20-100</td>
<td>2000</td>
<td>10-20</td>
</tr>
</tbody>
</table>

The limitation in this case is not the sustainability of the product, but the willingness of the client to pay for a certain lifespan/quality. The longer the lifespan (increase in value), the higher the impact is “allowed” to be. Like in many cases, the correct solution is usually found somewhere in the middle of the spectrum. Use good materials which should last the test of time but do not take risks with high impact materials which have uncertain end-of-life scenarios (Ahrend’s magnesium 360 chair). In the case of this closet however, it is more likely that when made of hard wood and finished with natural oils, like walnut or linseed, the eco-impact is even lower than the others. This is the intended EVR improvement.

Extending lifespan

Extending a product’s life is an excellent way to improve its sustainability characteristics. If the user is content with its presence no new product needs to (in many cases prematurely) take its place. However, making a product last long is more difficult than just creating a good product. During the first creative session some interesting points came to the forefront when thinking about extending the initial lifespan of a product. Terms like: “Timeless”, “Flexible” “Pretty” and “Self-repairing/healing” were mentioned.

The product lifespan is, however, usually not limited by their mechanical properties but rather by their aesthetic ones. A product can “last” much longer than its intended use indicates.
This can also partially explain the popularity of re-using products in case studies and modern design icons like Droog’s Chest of Drawers (MoMA and Museum of Art and Design in New York) by Tejo Remy and Decades no. 1 (Swedish National Museum of Art) by Wis Design. It is the eclectic aesthetics of these older products, which add value to modern solutions.

Since the modules are developed in such a way that they can be used independently of each other, they are able to take on multiple functions throughout its functional lifetime (which, unfortunately, is longer than its aesthetic lifetime; products being written off after a number of years our just because they have gone “out of fashion”). By making the modules in such a way that they can be re-used after their initial lifetimes by their primary buyers, less low-end (possible competition for middle to high end second hand furniture) would need to be purchased and thus produced. When comparing this to the theory of the EVR (Eco-cost to Value ratio) it can be argued to have a positive impact. The price for the second hand product would need to be within the range of the new low-end product for the theory to be fully supported, since the purchaser's expenditure needs to be fully covered as to prohibit any rebound-effect whereby money saved could be spent on a potentially less environmentally friendly product or products. To even out this possible and likely expenditure gap an after-sales service extension of the product could be provided to the buyer, as shown on pg. 81.

Other dilemmas include some contradictions that may only arise after time. The longer a product lasts, the more likely it is that it will be moved. In this case the transport impact needs to be added repeatedly. In general, it is thus advisable to consider this when designing for long-lasting products. Since this is not a proportionally high impact within the whole of the product LCA and since longer-lasting products may (not should) have higher eco-scores it may not be of such an importance.

**Damage control**

In terms of integrating self-healing properties into a particleboard closet, the S-Store only goes so far as to provide the ability to be partially replaced if a module is damaged. It is not uncommon in the project furniture industry for a closet to be replaced because of any damage it may have sustained. The modular build-up of the closet allows a single module to be replaced instead of having to replace the entire closet. In this way, only the extra-added impact of one module is added instead of an entire closet. Although such cases are the exception and not the rule, it is not

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90 Vogtländer, J.G, LCA-Based assessment of Sustainability: the Eco-costs/Value Ratio, 2010, pg. 85
uncommon to have to replace a complete closet. To really understand the effect, the impact of every “prematurely” discarded closet should be divided over the amount of closets made. When designing products that may be more sensitive to changes in trends and styles over (short periods of) time, flexibility can be a way to adapt to those changes. Stefan Sagmeister developed the appropriately named Darwin Chair (it shows through the different paper sheets the steps of evolution) and it tackles just this issue. This chair tackles the above mentioned problem of flexibility to changing demands. However, by doing so it still condones a throwaway attitude and needs a large amount of material to be made. An LCA of a simple wooden chair may prove it be much more environmentally friendly in a number of ways. Since the chair is made up of 200 sheets of Tyvek\textsuperscript{91} “paper” developed by Dupont it can only be recycled through them. In theory, the sheets made of DuPont\textsuperscript{TM} Tyvek\textsuperscript{®} print media can be filled in an envelope, “then seal and ship using the prepaid shipping label from your kit.”\textsuperscript{92} Using local ways of processing materials at the end of life will obviously reduce transport impact. Such specific recycling schemes have only been proven to work on large scales like that at Nespresso.\textsuperscript{93} The situation is not entirely the same however. In this case the aluminum is better to recycle than paper in the sense that paper cannot be recycled continuously and that the old coffee remaining in the capsule is used as compost and in biomass heat generators, which can compensate for the transport needed. Although Nespresso does offer the service of shipping capsules to them, they also have drop off points spread around their active markets reducing non-bulk shipping.

Ideally the flexibility should be found in the composition of the materials not only the amount. These modules can take on different compositions as the demand changes, without the addition or removal of materials.

**First and second life**

Fortunately, for Sagmeister, the environmental impact of the Darwin Chair is greatly improved now that it has become a museum piece. Since it is very difficult to make something with the intention for it to become timeless, like Sagmeister’s Darwin Chair, and “pretty” can be time/trend dependent, flexible product design is something that seems to be more accessible. Making something flexible increases the chances of it being useful after its initial use has been deemed fulfilled/written off. Make overs and remodeling of office interiors will most likely stay for quite some time and accepting that products have a premature end-date is the only way to think about what happens to it afterwards. The S-Store does not resist this phenomenon, however accepts it and tries to cope accordingly. When its initial use has come to an end it can be replaced. Thinking about its ability to fulfill a “second life” however, can result in its lifespan being extended. The smaller units (weighing only 8-9 kg’s) are more easily moved than larger versions of a similar closet. It was therefore the intention to keep the modules as independent as possible. If every module can function on its own (or preferably with a couple together) then some sort of afterlife may be possible. It is also for this reason that each tower should have its own top shelf, and not an extended shelf over the width of the predetermined amount of modules. This constrains the possibilities after its “first” lifespan.

\begin{itemize}
\end{itemize}
Design for Sustainability:

Since not all issues can be quantified by means of an LCA some standardized decisions should be made which can help in all cases. This is where the importance of having an adequate corporate vision becomes apparent. To be able to Design for Sustainability one needs to know what that means and what can be done to help in the process. Just as (Dutch) society has accepted the small and big flush buttons on the toilets so must other products and producers accept that sustainability can influence the way we use the products we need. This requires a paradigm shift, a change in the way we think about our needs and how we satisfy them. Such a shift often called upon in different theories for sustainable development, although it takes on many different forms; eco-efficient versus eco-effective, (consumeren versus consuminderen etc.)

The fact that no LCA or any other tool is 100% complete and able to completely define the environmental impact, let alone if something is sustainable, in an easy to use and understandable manner means that some issues must be confronted without fully comprehending the effects. This can partly explain the wider acceptance of Cradle to Cradle in the corporate world as a solution for “green” development. Some issues are neglected (less factors) and others are made black and white (simplification). In this way one can attach themselves to a “green” movement, which stimulates product development (revenue), raises brand value (revenue) while chanting: the way to a sustainable world is through eco-effective design, while this is almost possible, not nearly widely implemented yet. Only by nature. Sustainability, like reality is in fact much more complex. To make sure these factors are also included some assumptions and choices should be made. These choices can be defined within the company goals on sustainability which would then influence decisions made in product development. These include stances which need to be made about the use of certain materials and/or processes.

Future development:

As (global) demand increases for sustainable products, supply thereof should be expected to increase as well. Companies like Vepa, moderately progressive in their thinking, are frustrated that they do not have more corporate power to demand better solutions from their suppliers. Manufactures within the scale of Vepa have no real power in the market place due to the relatively small volumes they consume. (see analysis phase) They must wait until a supplier has received enough demand from larger players, like IKEA in the case for the material BeeTim (as described in Appendix 18: Material choice) for them to make any significant changes. It is therefore paramount that Vepa stays up to date in terms of materials development as it currently does, especially with increasing resource prices, Vepa and her shareholders are benefitted with price reduction through the use of less and/or different materials. It is important for a company to understand what influences environmentally “friendliness”. Which factors play a role and how they can be exploited. If they can ask the right questions and are not be surprised by the competition, they are already a step ahead. The insights given here therefore are hopefully a helping hand in their exploration towards sustainability.

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94 Interface calls it “Redesign Commerce” where by the economy has an understanding of sustainability and its needs, C2C calls it the “Next Industrial Revolution” where eco-effectiveness, making only more good things in stead of less bad things (eco-efficiency), is the key and product leasing services is a possible solution. Decoupling or delinking of ecology and economy whereby one is no longer (negatively) effected by the other is also used by Vogtlander and others.
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