CHALMERS

Turning Waste into Product Design

Rethinking Polyurethane Foam Waste as a Resource

Master of Science Thesis in the Master Degree Programme
Product Development

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Gothenburg, Sweden, 2013

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PREFACE

This report covers the documentation of a Master's thesis project (30 credits), carried out in the Master of Science in Product Development programme at Chalmers University of Technology, in Gothenburg, Sweden. As Kim has a Bachelor's degree in Mechanical Engineering and Sofia in Industrial Design Engineering (Swedish 'Teknisk Design'), the Master programme has served as a common part of both educations to be Civilingenjör (protected Swedish title).

This project is a part of the larger project "From Industrial Waste to Product Design" (IWtoPD), which is a collaboration between Chalmers University of Technology, Stena Recycling AB and the technical consultancy company Semcon Caran AB. We would therefore like to thank the following persons:

Chalmers: Andreas Dagman (examiner and supervisor), Isabel Ordoñez (coordinator of IWtoPD project) and Sandra Tostar (PhD at Chemical and Biological Engineering department). Furthermore, we would like to thank Oskar Rexfelt, Ulrike Rahe and Ralf Rosenberg who have been involved in the IWtoPD project.

Stena Recycling: Mats Torring (involved in IWtoPD project), Stefan Grönevik (Site manager in Värnamo) and Henrik Celander (Marketing at Värnamo).

Semcon: David Gillblom (involved in the IWtoPD project).

Others we would like to thank are: Christer Forsgren (Head of Technology and Environmental Science at Stena Metall AB), Göran Werner (Head of Technology at Carpenter Sweden AB), Shpresa Kotaji (Environmental Affairs Manager & Sustainability Expert at Huntsman Polyurethanes in Belgium) and Joakim Levin (Expert Adviser at PTS).

We would also like to thank all others that have assisted us in the project, answered questions, provided knowledge and in general showed interest in our project.

ABSTRACT

Today there are industrial waste materials that have no commercial value for various reasons. Many of these materials end up as landfill or go to energy recovery due to no incentive of recycling or re-use. The aim and objective of this project was therefore to find areas of application for the waste material *flexible Polyurethane (PUR) foam*. This required identification of possibilities and difficulties that the material offers when it comes to recycling. Furthermore, it involved development of several product concepts that utilize the PUR foam's various properties according to the identified possibilities.

The project is a part of the larger project "From Industrial Waste to Product Design", which is a collaboration between Chalmers University of Technology, Stena Recycling AB and the technical consultancy company Semcon.

The pre-study showed that PUR foam beneficially can be recycling through what is called rebonding; a recycling process that results in a foam of higher density than the virgin foam. A creative process resulted in a wide range of ideas on possible areas of application for the recycled material. The ideas were categorized into five categories according to what material property they primarily utilize; compression & softness, sound absorption, thermal insulation, fluid absorption, shock & vibration absorption and, lastly, other (non-property oriented ideas).

The generated ideas were screened by evaluation on a set of criteria, namely *Feasibility, Suitability of the material's properties, Estimated utilized volume and market potential* and *Degree of downcycling*. The screening was done in several steps, and additional information was gathered when needed in order to evaluate all ideas equivalently. This process narrowed down the ideas to one promising idea within each category. The screening was followed by a market analysis where potential user categories and market potentials were identified. Four ideas (product categories) were further selected for development of product concepts. The first concept is a modular screen-wall system for fairs and exhibitions where the rebonded foam is used as a flexible, sound absorbing panel. The second concept is a lamp where the lampshade is made from thin sheets of rebonded PUR foam, thus showing the visual properties of the material. The third concept is a set of large, soft playing modules for children. It consists of several modules, all on a forest theme, that can be used for playing, building, learning and as sitting furniture. Lastly, a pair of two product concepts of cooling bags was developed that are utilizing rebonded PUR foam as thermal insulation. All these products serve as examples on how to create a route for the material back into the market, and thus 'closing the loop' for the material.

An informative poster was created which summarizes the project and its findings; displaying information on PUR in general, detailed information on rebonded PUR foam and the possibilities in regard to feasible products. This could be seen as a summarized knowledge database on the findings from the project.

KEYWORDS:
Product Development, Polyurethane, Foam, Waste, Product Design, Resource, Research, Poster, Concepts.

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DENOMINATIONS

CC	–	Closed-cell
EOL	–	End-Of-Life
EPR	–	Extended Producer Responsibility
EPS	–	Expanded Polystyrene
LDPE	–	Low-Density Polyethylene
OC	–	Open-cell
PUR	–	Polyurethane

1. INTRODUCTION

1.1 Background

As the consumption of the society grows, more and more waste are produced – both from consumers as for manufacturing industries. A large amount of waste is produced in the mining, paper, steel and food industries. Metals, chemicals, plastics and other usable materials are still today considered to be waste and in fact only slightly more than 10% of all industrial waste is recycled. (Mistra, 2013)

There are industrial waste materials that today have no commercial value for different reasons. Many of these materials end up as landfill or go to energy recovery due to no incentive of recycling or re-use. It would therefore be of great value to find areas of application for these materials, as they are available in large quantities. This Master Thesis aims at solving this problem for the polymeric material PUR (polyurethane) foam at Stena Recycling; a company working with innovative recycling for all types of material and industries. As the PUR foam that Stena Recycling is handling today is destined to energy recovery, it would be valuable to create a route for the material back into the market, both from a business and sustainable point of view.

Mistra is a foundation engaged in how to deal with challenges regarding environmental issues and the usage of natural resources. They are funding a range of projects and research within this field through different initiatives, one amongst is called Mistra Closing the Loop. This initiative is financing a project called From Industrial Waste to Product Design (IWtoPD), which involves Stena Recycling, Semcon (an engineering consultancy company) and Chalmers University of Technology. It is realized through several different master theses at Chalmers that are aiming at finding areas of application for different waste materials, resulting in product concepts that utilize the materials in beneficial ways. Furthermore, it will render knowledge about the methodology surrounding these types of development projects, which differ from traditional product development projects as they need more up-front activities due to vague design objectives (Ordoñez et al., 2012).

About Stena Recycling

Stena Recycling has its headquarters in Gothenburg and is a part of Business Area Recycling within the Stena Metall Group. With close to 100 recycling facilities all over Sweden (reaching from Kiruna down to Trelleborg) and an annual processing amount of 2,5 million tons of waste, Stena Recycling is one of the leading recycling companies in Sweden. This amount includes waste from both consumers and production. (Stena Recycling, 2013)

Mistra Closing the Loop

”Mistra Closing the Loop” is a program that is dedicated to design methods for taking good use out of waste from industrial processes. This in order to save natural resources, create an added economic value and increase efficiency of industries. (Mistra, 2012)

Director of the program, Evalena Blomqvist, describes the vision of the program: *"Closing the loop will provide a more open minded and innovative thinking. Instead to see worn-out products, we shall describe material flows and technical properties, and to try finding new markets for recycled material"* (Mistra, 2013)

1.2 Purpose and objectives

The purpose is to increase the use efficiency of material resources; that is, to re-route material resources back into the loop. In this project it is to be done through product development by finding applications for where and how the material resources may be utilized. The solutions should be applicable both industrially and economically. It could be through either new innovative products as well as already existing products where the recycled PUR foam replaces another material.

From the purpose the following objectives are derived:

- Investigate possibilities of recycling PUR foam and its properties in its recycled state.
- Compile data of the material.
- Investigate which possibilities that are of greatest commercial value.
- Develop product concepts according to identified possibilities.

1.3 Limitations

The depth of the first phase of the project, where the analysis of the material will take place, will be limited by the amount and availability of information. The main focus of the project is the second phase project, which is the product development process. Decisions made in the project have therefore been forced in a certain direction to take this into account; such as investigating and choosing which recycling method to focus on. Furthermore, the resulting product concepts will not be developed in detail and no physical prototypes will be made.

1.4 Scope

The questions that this thesis is to answer are the following:

- *How can recycled PUR foam be beneficially utilized for competitive products with a commercial value?*

- *In what ways can the gap between disposal and manufacturing of new products be closed for PUR foam; what are the possibilities today and what difficulties are the most prominent?*

The questions are targeting the purpose of the thesis which is to find possibilities for re-routing recycled PUR foam back into the market. In order to do so in a beneficial way, the solution needs to handle large waste streams and be cost effective.

1.5 Reader's Guide

In the 2nd chapter a description is given for the project process; what has been done, how and why it was done and in which order. All the methods and tools mentioned, that have been used in the project, are further described in the following, 3rd, chapter. In the 3rd chapter there is also theory regarding waste management in general and sustainability.

The 4th chapter documents the findings from phase I, which constitutes one of the larger working efforts of this project. That part of the report includes an introduction to PUR (polyurethane) and a more detailed study on soft and flexible PUR foam. This chapter is a summary and collection of material information that otherwise is hard to find from one source. It also includes a separate discussion regarding the knowledge base created and findings that determined choices made regarding the project.

The 5th chapter shows and describes sequentially the results from the product development phase. The 6th chapter is dedicated to present the final results of the project; including detailed descriptions of the developed final concepts and an informative poster which summarizes the project. The two last chapters; 7 and 8, presents a discussion and conclusion respectively, in which the whole project and its results is being treated.

2. PROJECT FRAMEWORK – DESCRIPTION OF THE PROCESS

This chapter provides an overview of the project's process; how the project may be divided into separate phases and an explanation on what each phase includes.

Typically, a product development project origins in finding a solution to a problem, including satisfying a market demand and/or customer need. During the development process, a material is then selected based on its properties and the requirements in the given case. What differentiate this project from such a scenario is that the material in this case is already decided and a problem or demand for it is to be identified.

The method used for the process of the project is based on an approach proposed by Ordoñez et al. (2012), which is specifically adapted for an expanded design process that starts with a given material instead of a market need or similar, as often is the case of a traditional design process. The method suggests an extra initial stage where the starting point is the waste material and the output is design objectives, which then can serve as a starting point for a traditional product development process. This pre-process is illustrated in the figure below.

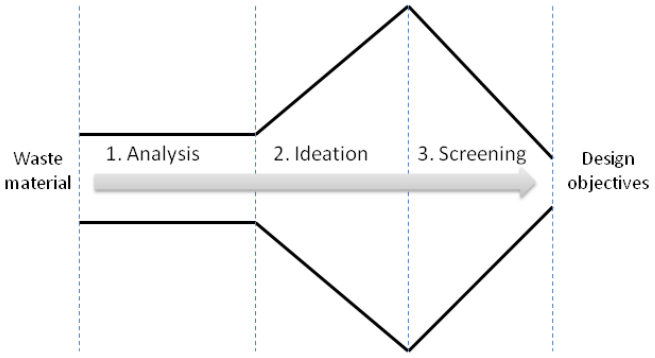


Figure 1. The initial stage of the project (Ordoñez et al., 2012)

The above mentioned process is in this project divided into two phases; phase I includes a pre-study (analysis) focusing on eliciting information about the waste material (step 1 in the figure above) and phase II which involves establishment of design objectives through ideation and screening (steps 2 & 3 in the figure above). Phase II is then expanded and continued with more of a traditional development process; including for example concept generation and refinement, visualization and evaluation. Such a model is exemplified by the figure 2.

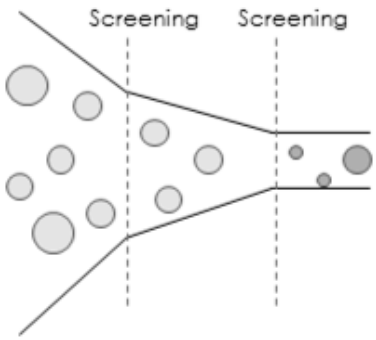


Figure 2. Adapted from Wheelwright and Clark (1992)

2.1 Phase I – Pre-study

The analytical part of the project involved data collection about soft, flexible PUR foam. Information was gathered through meetings with polymer experts at Stena Recycling, material and chemistry engineers at Chalmers and through study of publications and literature on the subject. To provide further understanding of the material and recycling in general, a study visit to one of Stena Recycling's waste management plants was done, and manufacturers of PUR foam were contacted. Regulations surrounding the material were also investigated. All these activities provided information on material properties, possibilities and limitations. Phase I resulted in an understanding of the material and proper documentation of its properties.

2.2 Phase II – Product Development

Ideation and screening

The ideation utilized the data collected during phase I; as it describes the prerequisites given by the material, with a focus on finding applications of the material. In order to expand the amount and variation of ideas, both internal and external idea generation were performed. The internal idea generation was done through brainstorming and exploring product catalogues of different retail stores, which provided useful inspiration.

The external idea generation was realized through a workshop with participants of different expertise, who were divided into two groups. Each group was given a so called "material box" which contained papers, sticky notes, pencils of different colors, material samples and an envelope with pictures of the recycled material in various product applications. The idea of providing the groups with such a box is proposed by Li & Kääpä (2013) who in their Master of Science Thesis explored the methodology surrounding product development projects with waste material as a starting point.

The procedure of the workshop started off with an exercise with focus on quantitative brainstorming. During the second ideation exercise, a random word generator was used as stimulus. After this exercise both groups sorted out the most crazy and unfeasible ideas. These ideas were then interchanged between the groups and each group was assigned to

make the ideas more feasible or take inspiration from them to create new ideas. The final assignment given to the participant was to choose five favorites for each group and visualize these by drawing posters. To identify a winning idea of the workshop, the posters were first showcased. All participants were then given three coins each to invest in their own personal favorites that they believed were the most promising and commercially viable ideas.

The screening and evaluation of the ideas from both the internal and external ideation was done systematically in several steps. The ideas were divided into categories of material properties, and the number of ideas was narrowed down within each category with regards to a number of screening criteria, as follows:

- *Feasibility*
  Feasibility was considered by judging if the idea had potential to be developed into a promising concept. Information was gathered when needed in order to create a reliable decision basis, which also minimized the risk of discarding concepts with good potential that was not seen due to lack of knowledge in the specific area.

- *Suitability of the material's properties*
  The suitability of the material's properties for the different applications was considered by looking at how well it would perform in comparison to current utilized materials. This aspect is important since it identifies reasons to use the material beyond the fact that it is a way to extend the life of or close the loop for waste material.

- *Estimated utilized volume and market potential*
  The estimated volume of material that each idea could utilize is connected to the market potential. A large potential market means larger volumes of utilized material, but it is also affected by how much material each product would contain or consist of.

- *Degree of downcycling*
  The criterion of degree of downcycling was taken into consideration as it is of great importance that the final product concepts suggest a beneficial way to utilize the material and not one that results in even worst environmental stress and EOL (End-Of-Life) situation than what is occurring today. Each idea therefore had to be compared with the current EOL treatment as well as with the competing ideas. The aspects of estimated product life length and consequences of mixture and involvement of other materials and chemicals were also considered.

The final product categories were then used as design objectives in the continuation of the project.

Development of product concepts

The remaining part of Phase II involved development of product concepts (for each chosen product category) and can be seen as what Clark and Wheelwright (1992) describes as an innovative and focused development funnel (also referred to as a Model III funnel).

The design objectives were used to once again broaden the funnel of ideas, but this time within the decided product range. Before starting the ideation, a market analysis was performed in order to understand needs and requirements, and to later ensure the competitiveness of the product. This was done through identification of user categories, investigations of available products and estimations of market potential.

The ideation was achieved by brainstorming sessions followed by morphological matrices (also known as Concept Combination Tables) where concepts are produced systematically by combining sub-solutions, from the ideation, into various new holistic concepts (Ulrich 2012). A screening process of the produced concepts was done in regard to the results of the market analysis. The screening was performed by evaluating the produced concepts in a Pugh matrix; which was iterated several times. Where the use of a Push matrix was not appropriate the evaluation was performed in regards to an imageboard and a list of criteria that needed to be fulfilled. The results from these evaluations served as a guide that showed which concepts that were more promising than others, and lastly the final concepts were chosen.

The final concepts were refined by improving those aspects that were identified to be inferior compared to other screened concepts. The designs were also taken further in order to achieve a higher level of detailed design. The final product concepts were visualized using CAD and digital sketching. Lastly, an informative poster was created, containing findings from the pre-study and presentation of identified possibilities including the final product concepts. The aim with the poster was to summarize the recycling possibilities of the material and communicated it in a graphical and accessible way.

3. THEORY, METHODS AND TOOLS

This chapter describes the methods and tools used in the project in a descriptive and theoretical manner; what they are used for and how they are put into practice. The first part consists of an introduction to waste management followed by a summary of sustainability and environmental models. After these sections, the theory and methods concern the product development process; starting with the creative process, idea generation and screening followed by market analysis, concept generation and concept evaluation.

3.1 Waste Management

The usage of the term "recycling" can sometimes be confusing as people may use it interchangeably with "reusing", but the emphasis of both terms is to effectively take care of waste by making use of the material over and over again. This leads in to the known phrase "Reduce, Reuse, Recycle", or "The 3 R's" which it is also known as. Below follows a brief description of these:

Reduce: The amount of waste created may be reduced by simply minimizing the use of resources; only buying/using products that are needed, are reusable, with less packaging, have multiple purposes (i.e. all-purpose cleaning product) and non-toxic (whenever possible). (Recycling Guide, 2013)

Reuse: The amount of waste created may also be reduced by reusing products several times (i.e. carrier bags and envelopes) or by finding new uses of old items (i.e. making covers out of old clothes or using newspapers as packing material). (Recycling Guide, 2013)

Recycle: Conservation of natural resources may be achieved by collecting and processing materials that has served its original purpose and turning them into new products. (Benefits of Recycling, 2013)

The 3 R's can be seen as a part of a larger, so called, waste hierarchy, which is illustrated in figure 3. It describes the most preferred order of actions according to the European Union. (Svantesson, 2012)

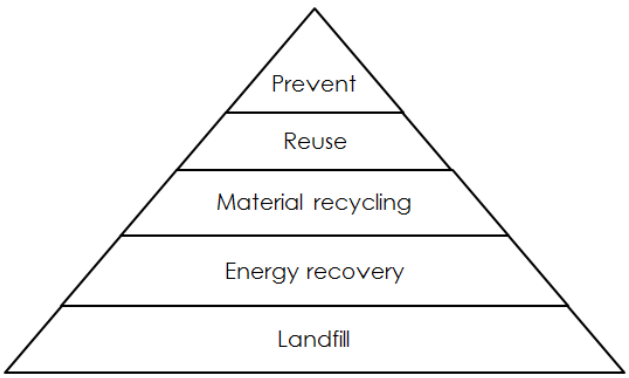


Figure 3. Waste hierarchy. Adapted from Svantesson (2012)

Figure 3 describes that prevention is the most preferred action, as it means to avoid creating waste in the first place. The waste created, despite preventive actions, should be reused to as high extent as possible and when that is no possibility anymore it should be recycled (e.g. be melted and reformed into a new component). When the material has served its purpose and none of the more preferred actions are possible anymore it is destined for final disposal; which is either incineration where energy may be recovered, or being placed on a landfill. Out of these two, energy recovery is the most preferred action as at least part of the energy can be regained, whilst landfill is a costly and unsustainable way to store waste.

3.2 Sustainability and environmental models

This section includes short descriptions of various terms that are widely used when discussing effects on sustainability and environment in regard to development. These are a just a few examples of models that show the environmental consciousness of today's society and the interest in working with sustainability issues in product development. Such models have been considered indirectly throughout the whole project process; what they stand for and their core values – especially in each screening and evaluation process.

Circular Economy

Circular Economy is a term created by The Ellen MacArthur Foundation which was established in 2010, that focuses on accelerating the transition towards a regenerative, circular economy. (Ellen MacArthur Foundation, 2013a)

*"A circular economy seeks to rebuild capital, whether this is financial, manufactured, human, social or natural. This ensures enhanced flows of goods and services. (*Ellen MacArthur Foundation, 2013b)

In figure 4, a system diagram is presented that illustrates what is called "the value circle" and the continuous flows of both technical and biological materials.

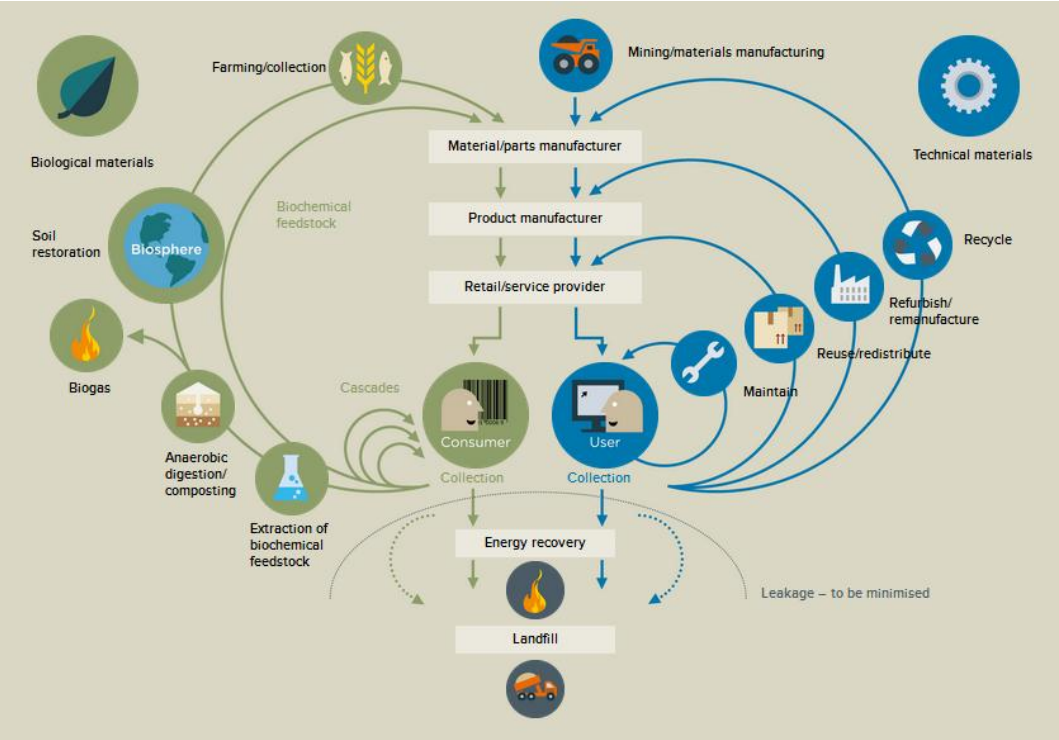


Figure 4. System diagram that illustrates a continuous material flow according to circular economy. (Ellen MacArthur Foundation, 2013b)

The diagram shows that energy recovery and landfill are regarded as a leakage that should be minimized to as large extent as possible, and by having an efficient "design" of each other process a restorative industrial system may be achieved.

Cradle to Cradle

Cradle to Cradle is a philosophy that was created by architect/designer William McDonough and chemist Michael Braungart in 2002, presented in their book *Cradle to Cradle: Remaking the Way We Make Things*. MBDC (McDonough Braungart Design Chemistry) describes how it can be seen as a framework that aims for improving and moving from being "less bad" towards "more good", in regard to sustainability. *"It expands the definition of design quality to include positive effects on economic, ecological and social health"* and its core principles are:

- Material health: Value materials as nutrients as safe, continuous cycling.
- Material reutilization: Maintain continuous flows of biological and technical nutrients.
- Renewable energy: Power all operations with 100% renewable energy.
- Water stewardship: Regard water as a precious resource.
- Social fairness: Celebrate all people and natural systems. (MBDC, 2013)

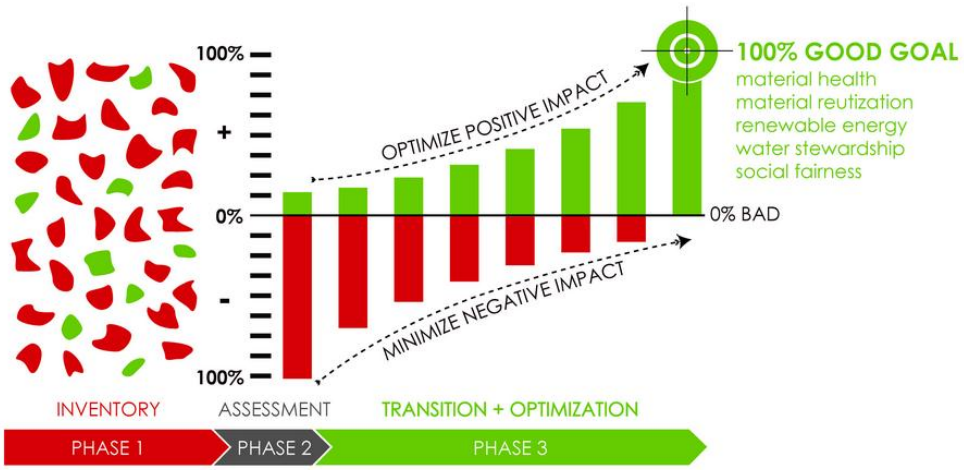


Figure 5. Cradle to Cradle continuous improvement strategy (MBDC, 2013)

3.3 The creative process and workshops

When generating ideas, it is often quantity and not quality that is in focus. According to Michanek and Breiler (2007), the creative process has four building blocks that are essential for a successful outcome: knowledge, mental environment, physical environment and methods. Knowledge of the area that an idea generation is focusing on can provide a solid foundation for the creative process, as persons with specific competences and connection to the project feel motivated about achieving good results, which can spur the motivation of others. It is however important to remember that a mixture of persons with different competences and personality will create a dynamic group with higher potential of finding innovative solutions.

The physical environment is an important aspect to take into consideration when planning a workshop, as it highly affects the inspiration and creativity in the group. The mental environment can be described as the atmosphere in the group and the relationship between the participants. This environment will affect the way the level of energy changes during the course of the workshop. In order to get all the participants on the same page, everyone should be aware of the rules surrounding an idea generation session or workshop. These rules are:

- Participants should not criticise each other's ideas, but are on the contrary encourage to use each other ideas to develop them further or let them work as inspiration for new ideas.
- Focus on quantity and not quality. Have, preferably, a goal on numbers of ideas that the workshop should result in.
- Make sure that everyone knows the importance of constantly visualizing and documenting ideas, and provide the group with the right tools for it.
- Everyone should try to share their ideas as freely as possible, no matter how feasible they are. The participants are encouraged to be spontaneous and impulsive without further analysis of new ideas.
- It is allowed to interrupt each other. Participants do not have to raise their hand before speaking.

3.4 Idea generation and screening

There are several methods available which are helpful when generating ideas, as illustrated in figure 1, chapter 2. The methods presented in this section were chosen since they fit well into a workshop environment and they complement each other by offering different ways to encourage creativity. Methods which were used for categorizing and screening ideas are also explained in this section.

Quantitative brainstorming

Brainstorming is a common and useful method for idea generation, especially early on during a workshop session since it allows the participants to first explore and discuss their initial and more obvious ideas (Li & Kääpä, 2013). The basic idea of brainstorming is to let all the participants generate and share ideas freely within the group, which should ideally consist of 6-8 people (Osvalder et al, 2009).

Random word list

A random word list or random word generator gives unpredictable input for idea generation. By randomly being provided with a word and trying to come up with an idea that relates to it, one can explore areas that would otherwise not come to mind. The method can be used individually or in a group.

The relay baton

The relay baton is a method where the participants in a workshop first generate ideas either individually or in small groups. The documented ideas are then sent between the small groups or the individuals, and each idea is further developed (Michanek & Breiler, 2007). In order to boost the creativity, the ideas may be as crazy as possible, which creates a challenge for the group or individual who is to further develop the idea into something more feasible (Li & Kääpä, 2013).

KJ method

The KJ method is a method used for structuring data. The first step of the method is a label making step, where information, thoughts or concepts are documented one by one on note cards. In the second step the cards are first shuffled to obtain a random order. The cards are then grouped in categories or "teams". The grouping should be performed based on feelings and intuition instead of logic and linear thinking. When categories have been formed, each category is assigned a title. Larger categories can be formed by identifying families of categories, which also are given new titles. In the last step, a chart is created by identifying patterns between the categories. Relations and interdependencies between categories are visualized with arrows. The chart is lastly described verbally and by a descriptive text (Scupin, 1997).

Screening

Screening of ideas is preferably performed in steps. In an initial step the ideas are reviewed for completeness rather than being decided for go/no-go, thus determining what additional information that would be needed for a go/no-go decision. They are also checked for being in line with available technology and product market strategies. Their potential role in executing an aggregate plan as well as if they seem viable in regard to available development resources is also to be taken into consideration.

Ideas that are complete and have passed the first stage are reviewed for the go/no-go decision. At this second screening step, ideas pass only if they are determined to be feasible enough to be carried through to a market introduction. Thus competing ideas are often reduced to one and (promising) derivatives are bundled together (Clark & Wheelwright, 1992).

Imageboard

An imageboard (also known as moodboard) is a collage of pictures that visually communicates attributes and environments connected to a certain target group. The collage represents the target group's values and environments connected to them. It can be used as inspiration and guidance during the creative phase of a design process. (Österlin, 2007)

3.5 Market analysis

This section briefly explains approaches and tools that were considered when performing the market analysis.

Competitor analysis and estimation of market potential

A structured market analysis can provide useful information on potential market segments and user categories. An essential part of a market analysis is often a competitor analysis, where current solutions available on the market and patents are investigated. This renders understanding of technical solutions, price groups and user/customer categories.

The market potential is affected by possible changes in technology that may affect the product's usage and competitiveness. It is also connected to the yearly volume of sold items, which is affected by the rate of growth and the life span of a product. (Johanesson et al., 2004)

Perceptual map

A perceptual map is a tool for visualizing how competitive a product is with respect to different variables or attributes. The map represents how consumers *perceive* products, and is therefore called *perceptual* map. In most cases, the map is based on two attributes that are represented on one axis each. (Fripp, 2012) The attributes can be described with one word in each end of the axis, for example if the attribute is technology the extremes on the axis may be represented by "old technology" and "new technology". A perceptual map can therefore be useful when wanting to compare products on the market or within a product portfolio.

3.6 Specifying needs and requirements

A list of requirements may include both requirements and needs from companies (producers) as well as customers (users). The needs may also be rated in regard to each other and how important they are to be fulfilled. The requirements are often specified in measurable values and with a reference to the origin of the requirements and why, this to be able to trace the requirements if any uncertainties would arise. The list of requirements may be used to evaluate concepts so that they fulfill the requirements that has been established. (Johannesson, 2004)

3.7 Concept generation and evaluation

The methods and tools presented in this section are useful for generating and evaluating concepts in a product development process, as illustrated in figure 2, chapter 2.

Morphological matrix

Morphological matrices (also known as Concept Combination Tables) can be used for creating concepts or for further developing existing concepts. The method systematically produces concepts by combining sub-solutions from ideation into various new holistic concepts (Ulrich 2012). The new holistic concepts can obtain properties and advantages that were not found in the sub-solution when being viewed individually.

Pugh matrix

The Pugh matrix, as described by both Ulrich & Eppinger (2012) and Johannesson et.al (2004), can be used for evaluation and elimination of concepts. The method is performed in a matrix form, where concepts are evaluated in comparison to a reference concept. It works by first establishing a set of criteria and (randomly) picking one of the concepts as a reference. Then all the other concepts are compared to the reference and scored accordingly (better (+), same (0) or worse (-) for each criterion), which allows the concepts to be ranked. This process is iterated several times by using different reference concepts. The results from these iterations then serve as a guide that shows which concepts that are more successful than others. The benefits of using a Pugh matrix is that it provides the team with a structured way to make decisions, it provides a view on which criteria some of the concepts need improvement on, and the work is documented directly.

Scenario

A scenario (also known as persona) may, for example, describe a use situation of a product in an intended surrounding environment or describe a typical user of the product, how he or she uses it and what experience it results in. (Osvalder A-L, et. al, 2009) The scenario can clarify the purpose of the product, by serving as a guide during the development process, and work as communicative presentation material.

4. PRE-STUDY

This chapter includes general information about PUR, the material's properties, where and how it is used and applied today, how it is recycled and what end-of-life possibilities it offers. It first introduces PUR as a material group followed by a more focused section on soft, flexible PUR foam, as this is the material in focus.

4.1 Introduction of polyurethane

This section treats PUR as a material group, gives an overview of the material and further provides understanding of what makes it unique.

What is PUR?

Polyurethane (also known as just "urethane" or abbreviated PUR or PU) is the name for a polymeric material group with a wide range of characteristics and properties. When investigating polyurethane, various applications and forms are found, ranging from both solids to foams and hard/stiff to soft/flexible. This is illustrated in figure 6.

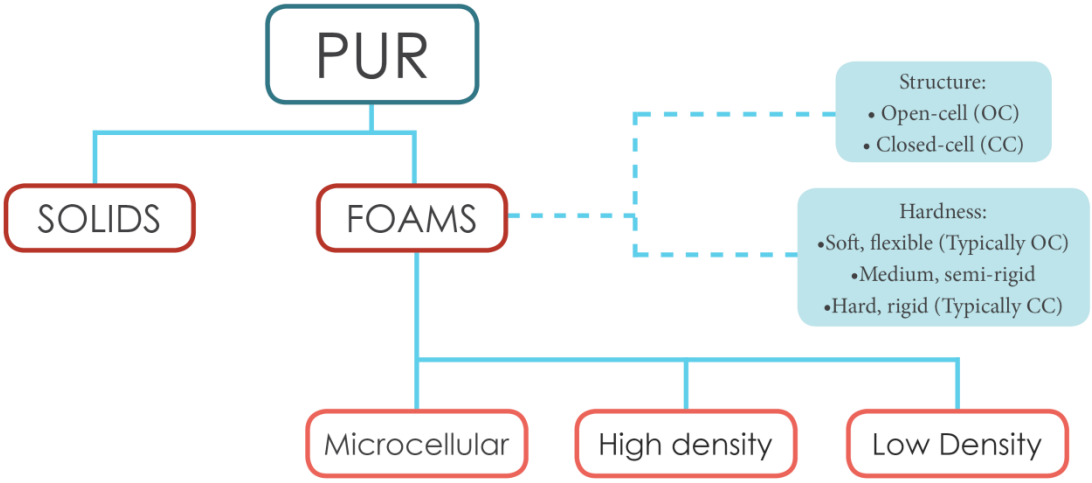


Figure 6. Illustrating identified categorization of Polyurethane

The material exists in form of thermosets and thermoplastics as well as elastomers and thermoplastic elastomers. This makes the material stand out from regular thermoplastics (Widén, 2008). Thermosets are polymers with a cross-linked molecule structure that doesn't allow the polymer to be melted and thus' to be reformed. Thermoplastics are polymers with a linear and/or branched molecule structure with weaker molecular bonds and may be

melted and reformed virtually countless of times. Elastomers are polymers that show elastomeric, rubber-like, properties. (Klason et al., 2006)

PUR is made from primarily two (liquid) components that when mixed react and form molecules of various sizes and positioning. How these molecules are bonded and formed may be altered into virtually any structure, which is the source to the material's very wide range of properties - much wider than the traditional thermoplastics, depending on its constitution and structure. (Widén, 2008) PUR foam may expand up to 30 times its initial volume during the reaction. (ISOPOL, 2013)

The two main components are polyol (polyalcohol) and an isocyanate; often TDI or MDI. TDI (Toluene diisocyante) is primarily used for making flexible foams, while MDI (Diphenylmethane diisocyate) may be used for flexible foams as well as semi-rigid and rigid PUR plastics. (BASF, 2013a)

Depending on which type of raw material (isocyanate) and additives that are used, and whether a blowing agent (substance used to create foam structure) is used or not, various forms and properties of PUR may be created. (ISOPA, 2013a) Density, mechanical strength, reaction time, cell structure, chemical and thermal resistance and adhesion are such properties that may be widely altered. (ISOPOL, 2013)

Foams are categorized as either open-cell or closed-cell foam. Open-cell foams are soft, as the cell walls are broken - allowing gases or liquids to pass through the material. Closed-cell foams' hardness depends on its density and is much stronger than the open-cell type as the cell walls are not broken and can take up the loads. Due to the cells being closed it also has a higher R-value (insulation capacity) and greater resistance to leakage. (Foam-tech, 2013)

What properties make it unique?

The ability to tailor the material into a wide range of combinations of properties is what makes it unique; as it may be solid or foamed, soft or hard and flexible or rigid. PUR foams have for example excellent thermal insulation capacity. Its comparably (to traditional insulation solutions) high R-value allows much thinner constructions and more effective use of space (ISOPOL, 2013). It also serves as an excellent sound dampener. (EnviroGreen, 2013) In addition to this, it is resistant to abrasion and corrosion, in the same time that it is lightweight, strong and durable. (ISOPA, 2013b)

Where can it be found?

Insulation

PUR can be used for a wide range of applications. Rigid PUR foam is commonly used as building insulation (for walls, roofs, floors, pipes etc.) as its properties are well suited for reducing heat losses in buildings as well as keeping them cool. By broadening the application of rigid polyurethane foam as building insulation with existing technology, the European Union could reduce its carbon dioxide emissions by 10% (ISOPA, 2013c). The material's high durability can also extend the lifetime of buildings, and its low weight makes it easy to work with. Furthermore, it is space efficient as building insulation, as it has the lowest thermal conductivity compared to all other insulates that are used on a large scale (ISOPA, 2011a). Compared to using one hundred millimeter of mineral wool, only fifty millimeter of

PUR foam is required for the same insulation capacity (ISOPOL, 2013). However, one of the reasons for why it is not as commonly used in Sweden as in the rest of the world is the high price compared to other alternatives and, according to parties with interest in PUR, that the building codes in Sweden promote polystyrene foam through simplified calculating values that creates a drawback for PUR foam (Widén, 2008). Other areas of application where the material's excellent insulation capacity makes it a suitable choice are for example in refrigerators and freezers, caravans and remote heating and cooling pipes.

Comfort and cushioning

PUR is widely used for making shoe soles, both within sports and trekking as well as in fashion oriented footwear. The greatest benefit of using PUR in shoe soles is the material's high durability, which provides shoes with long lifespan. PUR can also be found in car bodies; for interior and for insulating noise and heat from the engine. Seats and armrests are often stuffed with PUR for high comfort and durability. Similarly, it is also used as stuffing in furniture such as beds, sofas and chairs. One special type of PUR in beds is memory foam, which shapes after the body and therefore provides support (ISOPA, 2013c).

Coatings, adhesives and elastomeric components

Different from the previous examples, PUR is also used in coatings for a range of different applications; cables, vehicles, floors, wooden furniture, bridges and roads. It protects the surface from for example weather, corrosion and pollutions. PUR can also be found as adhesives, as it can bind together a wide range of different materials, and in paint. PUR elastomers can be used for many different applications, a few of which are wheels for trolleys and rollerblades, hoses, seals and gaskets (ISOPA, 2013c). Figure 7 summarizes some of the identified application areas for PUR in its different forms.

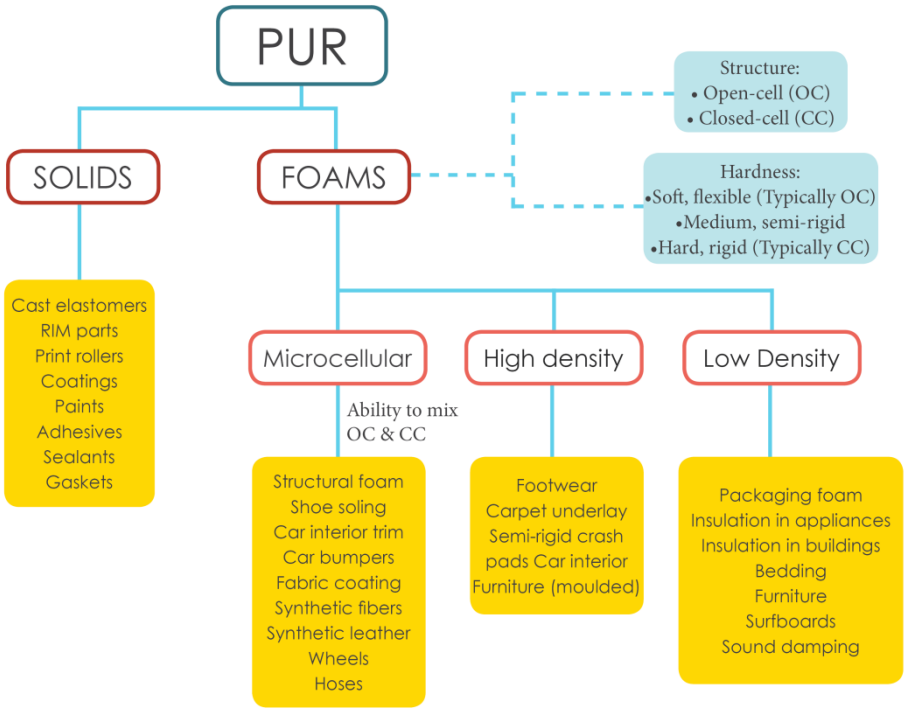


Figure 7. Illustrating identified examples of applications for each category of polyurethane

How can it be recycled?

PUR is recycled by mainly two different approaches, each with a set of various techniques, as follows below. (American Chemistry Council, 2013)

i. Mechanical Recycling - reusing the material in its polymer form.

Rebonding
Used with flexible foams; which are shredded into pieces and then bonded together with a binder. It is often used for producing carpet underlay, sports mats, cushioning and other similar products.

Regrind/Powdering
Industrial trim and post-consumer parts are grinded in various ways to form a fine powder, which is either mixed with a virgin material to create new PUR foams or for reaction injection molded (RIM) parts.

Adhesive Pressing/Particle Bonding
Parts from various applications, such as automobiles, refrigerators and industrial trim, are granulated and blended with either a powerful binder or polyurethane systems. Heat and pressure are then used to form boards or moldings. This results in products that are similar to a wooden chipboard which are used for sound proofing, water repelling furniture and flooring where elasticity is required.

Compression Molding
RIM and reinforced RIM parts are grinded into fine particles, which to heat and pressure are applied to in a mold. This method can produce products using 100% recycled content and with properties that are superior to the virgin materials.

ii. Chemical Recycling - returning the material into its various chemical constituent.

Glycolysis
Industrial and post-consumer PURs are mixed with diols, resulting in a chemical reaction that creates new polyols (one of the main components of PUR). These may retain the original properties and functionalities of the polyols which allows them to be reused for a wide range of applications.

Hydrolysis
Hydrolysis is done by creating a reaction between PUR products and water, which results in polyols and various intermediate chemicals. The polyols may then be used as fuel while the intermediate chemicals may be used as raw materials when producing new PUR.

Pyrolysis
In an oxygen free environment PUR is broken down to create gas and oils.

Hydrogenation
Hydrogenation is a similar process to pyrolysis, where gas and oils are produced through a combination of heat, pressure and hydrogen.

4.2 Soft and flexible PUR foam

This section is dedicated to more detailed information about soft and flexible PUR foam, including recycling procedures, trends, mechanical properties and key opportunities as well as challenges.

Figure 8. Picture of flexible PUR foam

Pre- and post-consumer foam

Soft flexible PUR foam (also referred to as comfort foam) can mainly be found in furniture, bedding and car interior, where it is used in seats. The virgin foam is manufactured through a (often continuous) process resulting in long foam blocks. The blocks are cut to smaller, manageable blocks which are processed further in accordance to the required shape (Recticel, 2013). When producing the foam blocks, the material reaches high temperature. The cooling of the surface creates a so called "skin" which has higher density than the rest of the foam block (PFA, 1994). The skin is often cut off and can be used as filler material if ground. When cutting the foam blocks into the final shapes, the generated waste is clean high quality foam. This foam is referred to as pre-consumer foam or production waste foam. When packing this foam for transportation, it can be either tightly wrapped and put on a pallet, or highly compressed in a container.

Post-consumer foam differs from pre-consumer foam in the way that its condition is depending on what it has been exposed to during its use-phase. The post-consumer foam can therefore contain for example skin flakes, dust mites, mold, bacteria and body fluids. This need to be considered when working with and recycling post-consumer foam, as it can cause problems regarding hygiene and health (ISOPA, 2012a). Furthermore, according to a leading furniture manufacturer, there can be traces of hazardous materials in the foam which can cause problems by not being within current legislations. The thresholds vary for different hazardous materials and within different industries and applications. It is therefore important to further investigate this aspect in the scenario of introducing a product made from post-consumer foam.

How important it is to sanities the foam during recycling is dependent on what type of application it is intended for. Sanitizing the material requires both time and equipment which makes it less attractive to recycle compared to clean pre-consumer foam. Christer Forsgren (2013), head of technology and environmental science at Stena Metall, highlights another problematic aspect of recycling comfort foam; which is the high level of flame retardant applied to it in some applications. However, with strict laws and regulation in Sweden and

Europe, it is mainly an issue in the USA and other countries where more types of flame retardants are accepted. When a material is to be processed or recycled, flame retardants need to be considered. When incinerated it would release brominated compounds that needs to be filtered away. These aspects would alter the situation in the furnace and put higher requirements on the equipment being used.

Recycling methods

There are two primary approaches to recycling of PUR foam; either mechanical or chemical. For both methods, the foam first has to be separated from other materials if it is post-consumer foam. Looking at how this is done for mattresses, it can be separated both by hand or automatically through shredding. Manual work is of course more labor intense, but it can also result in up to 90 percent recycled material from a mattress, which is more compared to what can be achieved automatically. When deconstructed by hand, the mattress is cut open by knife and hand tools are used for separating box springs, framing, foam and other components (American Chemistry Council, 2013).

Rebonded foam

There are a few methods used for mechanically recycling the separated foam, one of which is rebonding (also known as reconstituted foam, mainly in the UK). When rebonding the foam, it first has to be ground into small chips. A binder (usually a polyurethane binder) is then added, followed by applying pressure and heat to form blocks or other shapes. The blocks of rebonded foam can be cut and processed to obtain the desired dimensions. By adjusting the pressure and amount of foam chips, different parameters such as density can be obtained for the foam.

The mixture of colors is dependent on the color of the foam chips that the rebonded foam is made from. For pre-consumer foam, the flow of foam waste with certain colors can be kept separated, thus making it possible to affect the mixture of colors in the rebonded foam. As seen in figures 9 and 10, which show samples of two different manufacturers, there is a big difference in density, color and perceived quality.

Figure 9. Sample 1 of rebonded foam

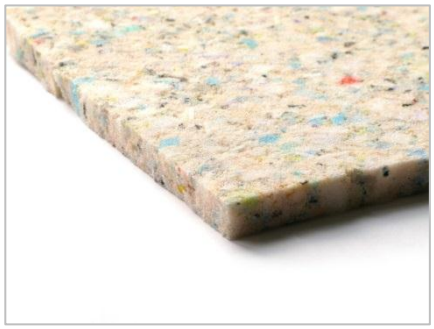


Figure 10. Sample 2 of rebonded foam

Regrind recycling

Another method is regrind recycling, which is done by first grinding the foam to a powder. The powder is then mixed with virgin material (as a filler material), and the mixture is used to create new PUR foam (American Chemistry Council, 2013). However, the amount of regrinded foam that can be added to the virgin material is limited to 10-20 % due to its

effects on the foam's physical properties and the viscosity of the formulation (Markovic & Hicks, 1997). Regrind recycling is an established and commercialized technology, but has not yet reached its full potential as it is still developing (ISOPA, 2012b).

Chemolysis

Chemical recycling of PUR foam can be done through chemolysis, which means depolymerization of the material. Three technologies can be used to break down the molecules to its building blocks. The methods are hydrolysis, aminolysis and glycolysis. When using these methods it is important to know the composition of the material, and it is therefore only used for recycling of pre-consumer foam. The three technologies use different reagents to break the urethane bonds in the material; water for hydrolysis, glycols for glycolysis and amines for aminolysis. The chemical process results in polyol which requires further processing before usage in different polyurethane applications. Glycolysis is the most developed and commonly used technology, and is applied and evaluated at both commercial and pilot scale in Europe. However, there have been difficulties regarding cost efficiency for large scale plants. The process of glycolysis involves a chemical reaction between polyurethane foam and diols (glycol) at a temperature around 200 degrees Celsius. The resulting product is two liquids; one flexible foam polyol which can be used for making new flexible foam, and one liquid which after treatment with propylene oxide can be used for making rigid foam polyol of high quality (ISOPA, 2001. ISOPA, 2012c).

Recycling market

Recycling of comfort foam has been a growing concern in many countries for a long period of time, as the amount of mattresses and furniture is high and the foam's low density makes it space-inefficient as landfill and during transportation. In Sweden, all comfort foam waste in furniture that is handed in at recycling stations is ground together with the rest of the furniture or framing of the product. This means that there is no separation of the foam from the other parts of the product. The reason for this is that it all is destined for energy recovery; comfort foam, wooden frames, (smaller) metal and plastic components in a grinded mixture. The recycling of materials like PUR foam is highly affected by laws and regulation in a country. It is for example not allowed to place combustible waste, including PUR foam, as landfill in Sweden today. (Naturvårdsverket, 2004) Figure 11 illustrates the main waste flow (globally) for PUR waste, both for production waste foam and post-consumer foam. The dotted line represents a not as common correlation, and is also where the need for a solution is biggest.

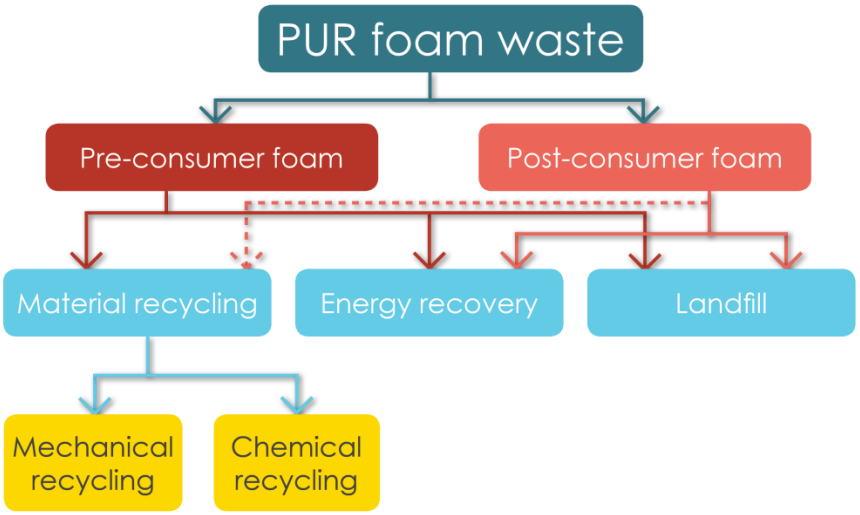


Figure 11. Main waste flow for PUR foam waste.
Adapted from information provided by industrial contacts.

Post-consumer comfort foam in the USA ends up as landfill or gets collected by or handed in to mattress recycling companies (LeBlanc, 2013), who sanities and grind the foam. Most of the foam chips are then turned into carpet underlay through rebonding, as its properties are suitable for this application; the recycled material provides durable comfort, sound damping and thermal insulation. The market for carpet underlay is big in the USA, and nearly 90 percent of all carpet underlays are made from rebonded PUR foam (American Chemistry Council, 2013). However, the market for wall-to-wall carpets in many European countries is not near as big, which affects the waste handling of the foam. It was found out through discussions with leading PUR foam manufacturers in Sweden that they today ship their production waste to USA or Europe (mainly UK) where it is rebonded. The rebonding is done internally by the company, meaning that they do not sell the raw waste foam to other companies but only the rebonded foam. Examples of areas of application that rebonded foam has been used for except as carper underlay are furniture cushioning, gymnastic and prayer mats, packaging material and plush toys (American Chemistry Council, 2013; Polyurethane Foam Association, 1994).

In the USA, there is a clear difference between how mattress recycling is dealt with in different states, showing that the link between recycling rates and legislation is greatly affecting the situation. Some states are for example applying the law of Extended Producer Responsibility (EPR) for used mattresses, to decrease the amount of mattresses that goes to landfill. The EPR is realized through making the manufacturers pay for the collection and recycling of used mattresses. However, this way of dealing with the issues in the USA has been widely criticized by the International Sleep Products Association (ISPA) for being inefficient and costly. ISPA are instead encouraging the development of a national system for mattress recycling with uniform rules that they believe would be more consumer friendly and economically efficient (ISPA, 2012).

Quantities of available resources

Knowing what quantities of PUR foam there are available for recycling is of big interest when developing a product that is meant to utilize it. *How large quantities of PUR foam waste are there? How large portion is available for recycling? In what condition is the material?*

According to MarketsandMarkets, the global market for PUR was estimated to ~13.65 million tons in 2010, as seen in figure 12, and is estimated to grow to ~17.95 million tons by 2016. The largest share of these quantities is flexible foam; which stand for about 37%. (MarketsandMarkets, 2011) This means that there in 2010 were about 5 million tons of flexible foam and will be about 6.6 million tons in 2016 (assuming the growth rate is the same for all shares; i.e. the share of flexible foam is the same in 2016 that it was in 2010).

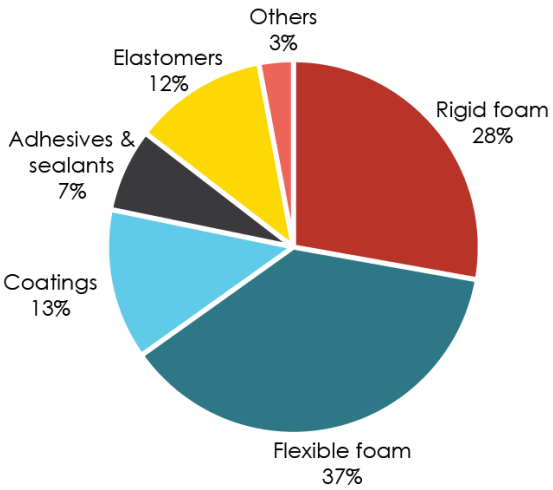


Figure 12. Global PUR market by product types 2010
(Adapted from MarketsandMarkets, 2011)

It has proven hard to estimate total quantities of available soft flexible foam in Sweden, due to several factors which are discussed below.

No recycling system for PUR foam:

Currently there is no system for recycling of post-consumer PUR foam in Sweden other than energy recovery, as described in the previous section. As it is not separated in the recycling process there exists no statistics on quantities that goes to energy recovery, and thus no potential estimated quantity may be verified.

Lack of statistics:

There are no clear statistics for amount of products where the (virgin) PUR foam is being utilized (i.e. mattresses, beds, sofas, chairs, etc.). Also, if such numbers would exist, it would be hard to estimate the amount of material in each product.

Widespread material:

Statistics may be found for raw materials used for producing PUR. However, this information would not be very helpful as the raw material is also used for purposes other than production of soft and flexible PUR foam, since PUR exists in various different forms.

Recovered statistics of available resources

One possible way to identify quantities is to research quantities of individual producers/manufacturers of soft PUR foam. Unfortunately this would be a very time consuming and ineffective process, which is not conducted in an extensive measure in this project. However, for documenting some rough figures, a leading flexible PUR foam manufacturer in Sweden reports producing about 4000 tons of flexible PUR foam per year. The same company claims that within their business there is 15-20% waste (from cutting etc). Using this data as a guideline together with the numbers for global market (previously presented) it could easily be calculated that this waste provides a potential amount (upper limit) of 0.75 – 1 million tons of *clean* foam from production (pre-consumer foam), globally. Remaining 4 – 4.25 million tons (80-85%) could be seen as potential post-consumer foam, which would require sanitation.

Properties of rebonded PUR foam

As described in section 4.1, the range of properties for PUR is wide, even within the spectrum of only soft and flexible foams. The properties of rebonded foam are therefore very dependent on which virgin foams that it is created from. However, ISOPA specifies the following typical properties for *rebonded* foam (ISOPA, 2011b):

Property	Value range	Unit
Density	60 – 300	kg/m^3
Tensile strength	40 – 150	kPa
Elongation at break	50 – 90	%
CLD hardness (10%)	4 – 20	kPa
CLD hardness (25%)	5 – 50	kPa
CLD hardness (50%)	15 – 150	kPa

Table 1. Properties of rebonded PUR foam

Note: CLD (compression load deflection) is one of the hardness indications being used. The percentage indicates the level of compression of the material. Another type is ILD (indentation load deflection). (Sydney Heath & Son, 2013)

Many manufacturers often specify rebonded foam only by its density. One of the largest (virgin) PUR foam manufacturers in Sweden claim that rebonded foam normally has a density in the range of 100 - 140 kg/m^3. This can be compared with *virgin* flexible PUR foam which has a density of 12 - 100 kg/m^3. (Plast- & Kemiföretagen, 2002)

Challenges in obtaining data on properties

What just has been described above can also be seen as challenges when investigating the physical nature of the material. Properties varies between manufacturers as they use different mixtures of virgin foams, and manufacturers often only have documented density for their own rebonded foam, which creates challenges in obtaining the data. Furthermore, the properties can vary widely with how much pressure and foam chips that are used during the rebonding process and obtaining accurate data would thus involve a large number of tests for different densities.

Prices and costs

Through discussions with a large PUR foam manufacturer, the price of virgin PUR foam from a large producer is approximately 2,5 €/kg. No numbers on the manufacturing cost of it has however been found. With the current (2013-05-13) exchange rate being 8,5511 SEK for 1 EUR (ECB, 2013), this translates to 21,4 SEK/kg. In comparison, rebonded foam is sold for 2-3 €/kg, which with the same exchange rate translates to 17,1-25,7 SEK/kg. The rebonded foam is with other words in the same price range as virgin PUR foam, but can differ both under and above the price for virgin PUR foam. The same source provided information that the cost for producing rebonded foam of pre-consumer foam is approximately 1 €/kg, which translates to 8,6 SEK/kg. Numbers on the cost for producing rebonded foam of post-consumer foam has not been found, but are of course higher than for pre-consumer foam due to separation and sanitation.

Summary of characteristics

The summary shown in the table below can quickly communicate the most important characteristics for rebonded foam and how it differs if it is made from pre-consumer (production waste) and post-consumer foam.

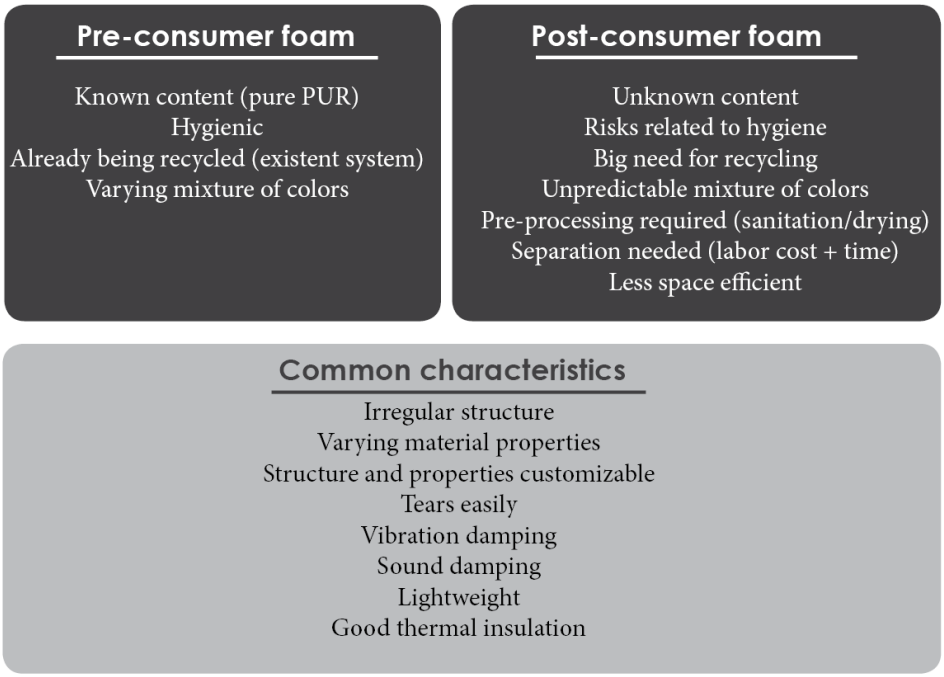


Figure 13. Summary of characteristics

4.3 Discussion of Pre-Study

The pre-study has provided a solid foundation of knowledge about the material which is crucial in order to move on to the creative phase of the project. It has also opened up for a few standpoints that need to be considered in the continuation of the project. The findings about differences in pre- and post-consumer foam have broadened the content of the project as the business opportunity of utilizing the two flows differs significantly. A decision of focusing on one of these flows would narrow down the scope of the project but also limit the amplitude of the result.

The study of different recycling methods for soft PUR foam resulted in a decision to focus on shredding and rebonding for the idea generation. The other recycling methods are much more about breaking down the material into its raw constituents to be able to use these in production of new "virgin" foam. Focusing on the other recycling methods would effectively change the objectives and steer the project into focusing on solving a chemical challenge, rather than product development; which is the main focus of this project. The choice of focusing on rebonded foam does however not imply that rebonding is the ultimate way to handle the foam waste. If chemical recycling can be performed successfully (with regards to quality, environment and economy) it would be a more sufficient way to close the loop for the material compared to rebonding. However, the method of rebonding does not exclude that the rebonded foam in a future EOL treatment can be handled with chemical recycling and thus turned into new, PUR foam of high quality.

Another aspect of using rebonding for recycling of PUR foam is that one becomes dependent on a waste flow rather than closing it, as with chemical recycling. If a product is made of rebonded *pre-consumer* foam waste and the demand for it increases, it would require more waste from the production facility that generates the waste. This would also discourage a reduction in waste which is contradictory to the reasons of recycling the material in the first place. However, this aspect may be involved in the business plan by planning for it and making it a part of the brand to take care of and decrease waste flows in industries. In such a situation it would be important to foresee the changes in the waste flows that one is dependent of and being able to quickly adjust to them.

The pre-study also gave insight in the availability of data and information about PUR foam and its recycling possibilities. ISOPA (*European Diisocyanate and Polyol Producers Association*) turned out to be the most accessible source of information, but it still required a lot of time and effort to capture the whole picture of recycling possibility and the market today for soft PUR foam. This further motivates the creation of an informative poster as a deliverable of this thesis project as it can provide an overview over relevant information and communicate important aspects of the subject.

Lastly, there is limited information available on how the market is developing in Europe. There is more documentation of the situation and market in the USA. A more local solution than shipping the waste to other countries could increase the efficiency and cut costs. This would require to either find smaller manufacturers who are not currently recycling their waste and who would be interested in selling their waste, or to introduce a business proposal to leading manufacturers who already have a recycling system for it. Such a business proposal needs to clearly state how they (economically) can profit from the suggested solution.

5. DEVELOPMENT OF PRODUCT CONCEPTS

5.1 Initial ideation and screening

A full list of the generated ideas from both the workshop and the internal ideation can be found in Appendix I. After screening of identical and unfeasible ideas, there were in total 154 unique ideas generated which were categorized into six main categories (see figure 14) by performing a KJ analysis. These main categories describe various properties or characteristics of the flexible foam which the individual ideas primarily utilize.

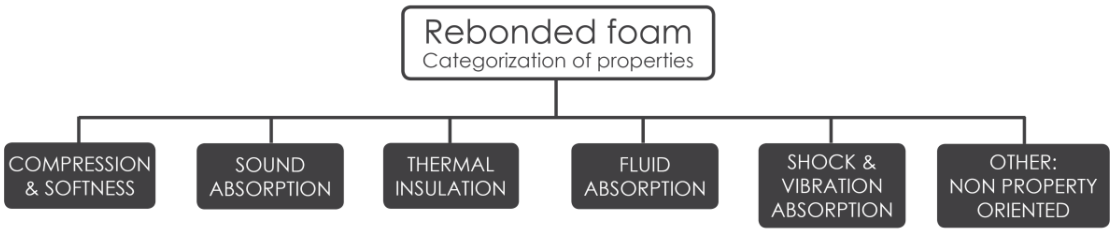
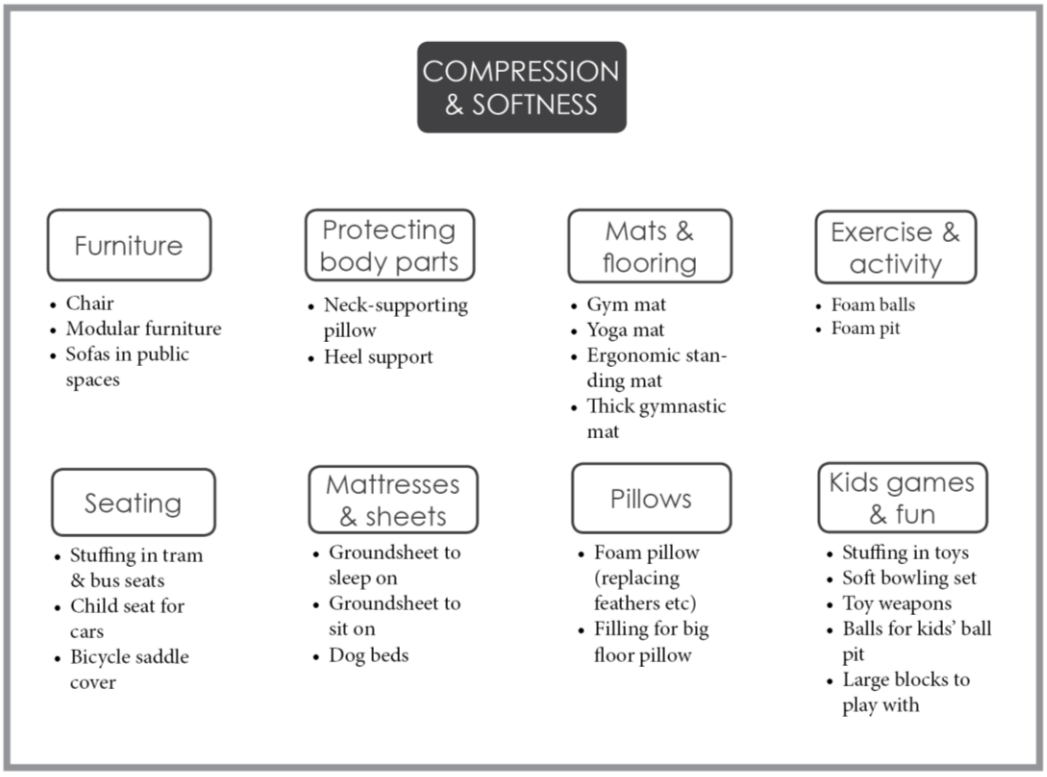
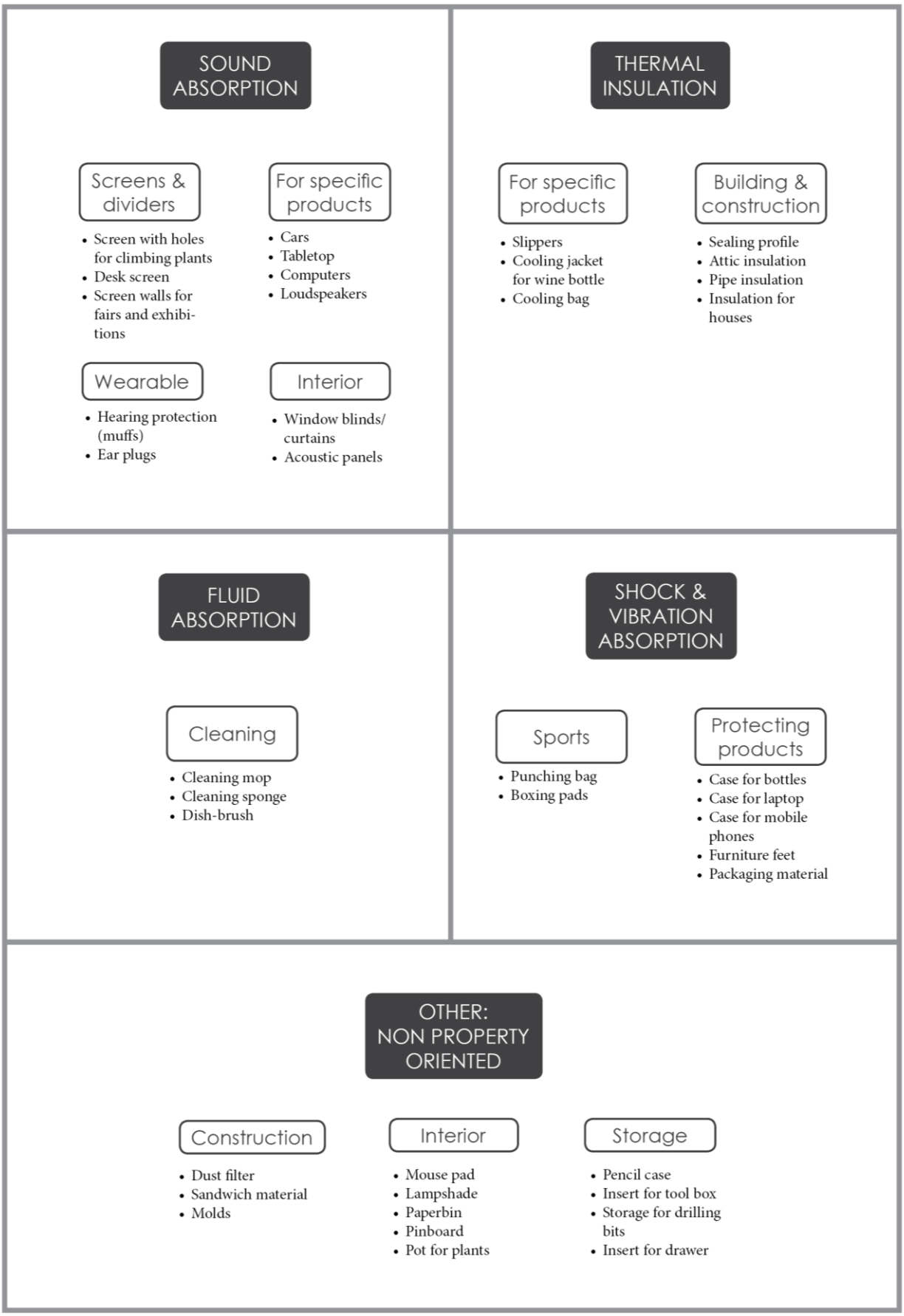


Figure 14. Categorization of properties

The ideas were further categorized into different themes. Below follows an overview of each main category, its themes and belonging ideas. The presented ideas are ideas that made it through the second screening, where the suitability of the material for the suggested product was evaluated. Where needed, additional information was gathered in order to evaluate all ideas equivalently.




SOUND ABSORPTION
Screens & dividers
• Screen with holes for climbing plants
• Desk screen
• Screen walls for fairs and exhibitions
For specific products
• Cars
• Tabletop
• Computers
• Loudspeakers
Wearable
• Hearing protection (muffs)
• Ear plugs
Interior
• Window blinds/ curtains
• Acoustic panels
THERMAL INSULATION
For specific products
• Slippers
• Cooling jacket for wine bottle
• Cooling bag
Building & construction
• Sealing profile
• Attic insulation
• Pipe insulation
• Insulation for houses
FLUID ABSORPTION
Cleaning
• Cleaning mop
• Cleaning sponge
• Dish-brush
SHOCK & VIBRATION ABSORPTION
Sports
• Punching bag
• Boxing pads
Protecting products
• Case for bottles
• Case for laptop
• Case for mobile phones
• Furniture feet
• Packaging material
OTHER: NON PROPERTY ORIENTED
Construction
• Dust filter
• Sandwich material
• Molds
Interior
• Mouse pad
• Lampshade
• Paperbin
• Pinboard
• Pot for plants
Storage
• Pencil case
• Insert for tool box
• Storage for drilling bits
• Insert for drawer

The final screening was achieved by judging how well each idea performed on the following criteria (as explained in section 2.2); Feasibility, Suitability of the material's properties, Estimated utilized volume and market potential, and Degree of downcycling. Furthermore, the final screening was performed with the aim of obtaining a diversity of products of different kinds, in order to show a range of various possibilities of the material. One product category was finally chosen for each material property respectively, with the exception of liquid absorption as the ideas in this category were not fulfilling the criteria to a desired level. The five chosen product categories are *packaging material, screen-walls for exhibitions and fairs, cooling bags, large soft playing modules for children* and *lamps*.

5.2 Design objectives: choice of product categories

Screen-walls for exhibitions

PUR foam is a relatively light material which can be used for sound absorption due to its foam structure. Furthermore, it is flexible and easy to process (e.g. cutting.) into various shapes. This grants opportunity to utilize the foam as a primary material in screen-walls, which absorbs sound and blocks of vision.

Everyone that has been at an exhibition or fair of reasonable size knows that the sound level can be quite high. On "Ljud, Ljus och Bildmässan" (The Fair for sound, lighting and picture) at Stockholmsmässan, Sweden, they have set a maximum allowed sound level of 75dB (LLB, 2012). However, 75dB is a quite high sound level to be exposed to during longer periods of time. This sound level is equivalent to somewhere between sitting inside a car and road traffic (AV, 2013). Therefore, a potential market would be to aim at exhibitioners who are in need for screen-walls that can absorb sound and create a pleasant atmosphere.

Packaging material

Since flexible PUR foam is open-celled it allows water and other liquids to pass through the material, making it unsuitable for an application with external exposure in packaging purposes. Thus the foam could serve as a dampening component in a packaging solution.

Cooling bags

The product category of soft cooling bags is highly suitable for rebonded foam as the material has good insulating capacity and low density. Cooling bags as a product category offers the possibility to specialize on storing either a wide range of food and beverages or to specialize on specific areas, for example to store a water or wine bottle. The visual appearance can vary greatly with different shapes and by using and combining different materials.

Rebonded PUR foam is suitable to insulate a cooling bag with as it has low thermal conductivity. Compared to polyethylene foam, which is used as insulation in other soft cooling bags, virgin PUR offers lower thermal conductivity at equal densities. No data is however available on the thermal conductivity of rebonded foam, as it depends on the quality of the recycled foam, the structure, the binder and what density it gets after processing. However, a high density foam will result in a higher thermal conductivity, and the rebonded foam should therefore be manufactured for having minimum density for this

application. The minimum density for rebonded foam, as stated in section 4.2, is 60 kg/m^3. The influence of the binder and the structure of the rebonded foam can be assumed to influence the thermal conductivity negatively, but by how much is unknown. Figure 15 shows a chart from the software CES EduPack (2012) which compares three types of polyethylene foam with three types of PUR foam of different densities regarding thermal conductivity. Even if the rebonding process results in relatively high increase of thermal conductivity, it would still offer the same insulating capacity as polyethylene foam.

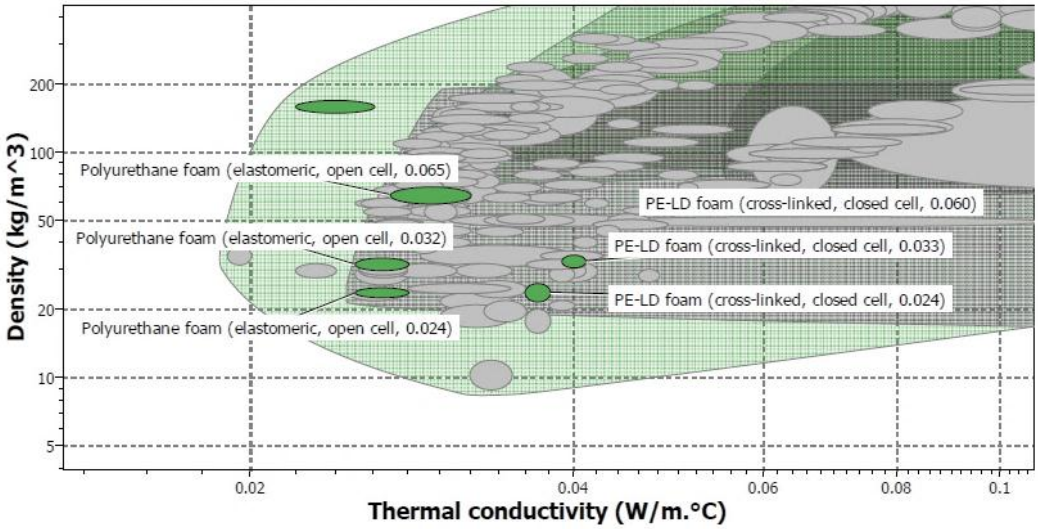


Figure 15. Material chart from Granta's CES EduPack (2012)

With a protecting layer of a polymeric film, the food stored in the bag can easily be protected and completely separated from the recycled foam. The foam will however need to be sanitized or cleaned if it is post-consumer foam in order to ensure a safe and hygienic product.

Large, soft playing modules for children

Large, soft playing modules for children involves different kinds of foam blocks and shapes that are meant for playing, building and learning for children of different ages. The blocks and shapes may vary in size and color, and can be sold either in sets or individual pieces depending on the type of activity it encourages. A single piece can for example be used as a large toy or rocking horse and may be shaped as an animal. A set of pieces can offer the possibility to build different constellations which open up for creativity whilst at the same time involving physical activity and learning.

Rebonded foam has several properties that make it suitable for large, soft playing modules for children. During the rebonding process, the density of the foam can be varied to a desired level, which is beneficial since different types of soft building blocks require different densities. Furthermore, the color of the rebonded foam can vary independently of the visual appearance of the product, since it has a cover, which makes it suitable to handle different types of waste flows. The hygienic aspect is however important to take into consideration. A sanitizing process may be required if the product has a detachable cover since this would then mean that the user has to interact with the raw foam when the cover is removed. If the cover is not removable, the question of sanitations is dependent on how much liquid and gas the cover let pass though. The product could thus handle both pre- and post-consumer foam but would require sanitation of foam of unknown origin.

Lamps

By using rebonded foam to create a lampshade, the visual properties of the material will be used and in focus. The appearance of the material can be varied with different densities and mixtures of colors. If the lampshade is to have a consequent color scheme over a whole production series, the recycled foam also need to be provided from the same source over time. This makes such a product more suitable for pre-consumer foam. Another aspect which is relevant is the hygienic issue of post-consumer foam. If the foam is exposed directly and close to the user in a home environment its cleanliness needs to be ensured which can be costly.

5.3 Market analysis and identification of requirements

This section contains a market analysis and choice of market segment for each product category. Furthermore, it contains identified needs and requirements which will be used as input for the concept development process that follows after this section.

Screen-walls for exhibitions

User categories

The users of this product are employees of companies that are attending exhibitions or fairs as well as visitors at the exhibition booth. Most user interaction would be with the exhibitioners who install the products and setup the display area, but they can in the same time affect the surroundings; both aesthetically and in movement possibilities (e.g. block off paths).

Screen-walls aimed at exhibitioners should be portable and customizable so that may be used for varying circumstances and situations in different configurations (used as different exhibitions and fairs with varying spaces and setups).

Product information & technical solutions

There are a wide range of screen-walls available on the market today. Documentation of screen-walls is therefore limited only to screen-walls that in its marketing is claimed to have sound dampening capabilities or that are suitable for exhibition purposes (either directly or through features concerning mobility and customizability). In this way only screen-walls that are aimed towards or suited for exhibition purposes are considered.

The various screen-walls found could be categorized into *single-panel types* and *multi-panel types*. Furthermore, they could be categorized in regard to mobility; *with or without wheels*. A brief summary of each category follows further down. For a full list of documented products, see Appendix II.

Most of the products that are available with a stationary base (without wheels) are also available with wheels, either by offering an alternative model or by an accessory. Therefore the summary below only distinguishes between single- and multi-paneled screen-walls. The most popular material throughout all categories is aluminum for the framing (for its low weight and aesthetics) and wooden boards and textiles (e.g. polyester) for the panels.

i. Single-panel types

These screen-walls are products only using single panels of various sizes; ranging from about 770mm to 1800mm in width and 1513mm to 1800mm in height. The base (that is the interface between the floor and the screen-wall) is often designed so that it is problematic to setup multiple screen-walls freely if put tightly to each other in an angle. The reason for this is that the bases clash into each other – resulting in a gap between the screen-walls (see figure 16). This is especially the case for the documented screen-walls with a base with wheels, as the base tends to extend more outwards.

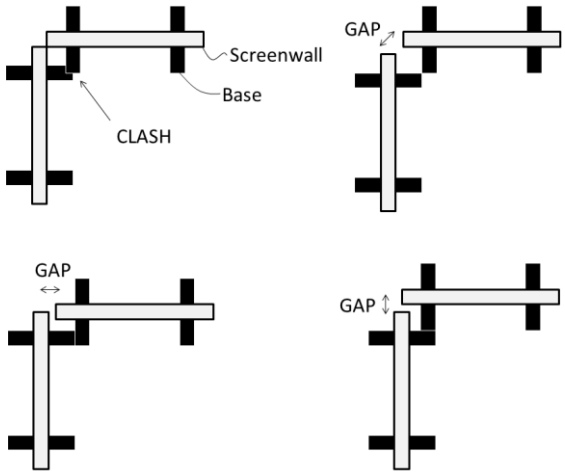


Figure 16. Illustrating problematic of gap and clash for screen-walls

The prices for the single-panel type screen-walls ranges between 1'115 to 3'188 SEK with an average calculated to 1'923 SEK.

ii. Multi-panel types

These screen-walls are products using two or more panels of various sizes; ranging from about 1010mm to 3750mm in total width and 1450mm to 1850mm in height. The screen-walls in this category do not have the gap and clash problem described for the previous category as they are screen-walls with multiple panels attached to each other. These are designed so that each panel may be rotated and put freely in various angles. Their bases are often designed so that they are easier to put tightly and freely next to another screen-wall without problems. The prices for multi-panel type screen-walls ranges between 1'120 to 17'625 SEK[1] with an average price calculated to 5'879 SEK.

Market potential

Since the market for the product category of screen-walls is already narrowed down to exhibitions and fairs, it will not be further specified. The market potential is based on the number of exhibitions, fairs and similar events that take place, how many exhibitioners and how big the need for screen-walls is.

[1] This max price includes a screen-wall plus required accessory and is calculated with 25% VAT. The price is calculated from the values found in the Appendix II.
[2] The sound absorbing capacity is a measurable value but needs to be further specified by performing

Below follows two examples that give an indication on how big the market is:

- At Stockholmsmässan there are each year around 60 industry/business leading exhibitions and 100 national and international congresses, conferences and other events, including 10'000 exhibitioners, 1,5 million visitors and 8'000 journalists. (Svenska Mässan, 2013)
- At Svenska Mässan (in Gothenburg, Sweden) there are each year around 30 exhibitions and 100 small and large congresses and conferences, including about 1 million visitors. (Svenska Mässan 2013)

These examples show statistics for two of the largest exhibitions of Sweden. Additionally there are other large and small exhibitions in Sweden, including Elmia in Jönköping and Malmömässan in Malmö.

Identification of requirements

Wishes are marked with a *, remaining descriptions are identified as requirements.

1. Good sound absorbing capacity[2]
2. Portable
   2.1 Time efficient to pack and unpack*
   2.2 Easy to understand how to install and disassemble*
   2.3 Lightweight – modules that can be carried
3. Simple interaction
   3.1 Easy to move*
   3.2 Allow locking position
   3.3 Allow multiple screen-walls to be combined*
4. Customizable
   4.1 Offer options to display information (e.g. posters, sheets)
   4.2 Available in different color schemes*
   4.3 Modular*

Packaging material

User categories

There are packaging solutions for private individuals as well as for corporate; ranging from smaller offices to large manufacturing plants and online shops. Nearly all types of products are packaged and transported both locally and globally; it could be either a CD album being carried in a backpack to a valve being transported from China to Sweden.

Product information & technical solutions

There are various packaging solutions available, depending on what to transport, where and how. The damping component may be in form of chips/flakes, sheets or blocks for various bags, envelopes, boxes and tubes in all thinkable sizes.

[2] The sound absorbing capacity is a measurable value but needs to be further specified by performing various tests and evaluations. A reference product (leading product on the market) could also be used to set a goal for the value.

Packaging solutions that are existent today may be grouped into 4 categories as follows. A more detailed list of currently available products (including prices, dimensions, etc.) is found in Appendix III.

i. Cushioned envelopes and bags

For these products both manufacturers and retailers interchangeably use the terms "bag" and "envelope". This product category consist of various envelopes and bags of either paper or plastic with a soft cushion layer of either bubble wrap, plastic foam or paper. The size of the envelopes and bags ranges from 95x165mm to 350x470mm, and the prices ranges from 0,75 SEK/piece to 80 SEK/piece. However, the product with this maximum value includes postage (in regard to its volume) and the next most expensive is rated at 14,68 SEK/piece.

ii. Insulation material

This category contains EPS (expanded polystyrene) boxes that are used for packaging cooled products as they have good insulation capacity. Sizes range from 140x100x200 mm (2,8 L) with a price of 33 SEK to 560x360x235 mm (28 l) with a price of 75 SEK.

There are also gel bags that are used as a filling material that can be cooled or heated to preserve temperature longer in the package. These are 165x140x31 mm, weights 450g and cost 22 SEK/piece.

iii. Cushioning/filling material

This category includes foam chips or papers which are wrinkled to fill out voids in the package, thus preventing the packaged item to move around during transport. It also includes foam sheets and paper sheets which are used to wrap around items to create a cushioning layer around the item inside the package. These types of products are sold in great quantities and example of batch sizes and prices of individual products are found in Appendix III.

iv. Pads

This category consists of various profiles and other geometrical elements made from EPS or LDPE (low-density polyethylene) for protecting edges and corners of packaged items. There are also blocks of corrugated paper which are mainly used as shims and structural support, but may also be used for the same purposes as the profiles described in this same category. As for the above category, these types of products are sold in great quantities. Examples of batch sizes and prices of individual products are found in Appendix III.

Market potential and choice of market

The market potential lies in replacing current packaging solutions used today – used by all user groups and in all market segments mentioned above. Instead of producing current packaging solutions in virgin materials, the recycled PUR foam could be used instead, which would not only enhance the PUR usage, but also decrease the need to produce virgin material intended for packaging.

A large market alone is the postage service which includes cushioned envelopes/bags and various mails and packages that contains some kind of packaging material. At many shops and kiosks in Sweden there are Posten's cushioned envelopes (with postage included) for sale which are widely used.

According to Trafa (2012), 2,77 thousand million mails (translated definition for mail: "addressed postal item enclosed by an envelope or any other cover which weighs less than 2kg, including postcards and similar") and 71,2 million packages (addressed postal items > 2kg) were sent in 2011. However, due to partly lack of collected statistics and partly due to secrecy in publishing such statistics there are no information on how many of these mails that are so called "thick mails" (cushioned envelopes and other mails containing items other than paper). Expert adviser Joakim Levin (2013) at PTS (Swedish Post and Telecom Authority) roughly estimates the number of "thick mails" to 10-12 million, out of the total amounts of mails. This results in an estimate of ~82 million postal items during 2011 that contained items other than paper. Assuming that all of these actually do contain items other than paper and do require some kind of packaging grants a large potential market.

Identification of requirements

Wishes are marked with a *, remaining descriptions are identified as requirements.

1. Good shock and vibration absorbing capacity
2. Lightweight
3. Flexible usage
   3.1 Offer protection for wide range of packaged items*
4. Space efficiency
   4.1 Efficient storage volume*
   4.2 Efficient transportation volume*

Cooling bags

User categories

There are several potential user categories for cooling bags, for example families, young adults, hikers and hunters. A family might value a cooling bag with large inner volume which they can easily carry with them to a picnic, to the beach on a sunny day or any other outdoor excursion. Young adults may value the aesthetics more if they want to use the cooling bag for picnics in the park together with friends. Hikers and hunters are more likely to choose a cooling bag which is comfortable to carry for a longer period of time, which offers more functions and is durable. The prices vary within each category and the different price options also attract different customers. Furthermore, user categories vary with the geographical location as weather and temperature affects the demand on cooling capacity and type of usage. Different geographical location also involves different cultures and norms that can affect what aesthetics that are preferred.

Product information & technical solutions

40 soft cooling bags were included in the market analysis for bags on the Swedish market. All bags are available in online shops and on websites for different stores. The full list of bags can be found in Appendix IV. The bags were categorized into six different categories for different types of bags; picnic bags under 200 SEK, picnic bags over 200 SEK, picnic baskets, backpacks, for beverage and children's cooling bag. Bellow follows a table with the number of bags in each category and the average price. The full list in Appendix IV also contains information on volume for each bag and what retailer that sells it.

Category	Number of bags in category	Average price in category
Picnic bags <200 kr	15	110 SEK
Picnic bags >200 kr	5	395 SEK
Picnic baskets	7	146 SEK
Backpacks	3	383 SEK
For beverage	9	312 SEK
Children's cooling bags	1	75 SEK

Table 2. Categorization of cooling bags and average prices

The largest category is picnic bags under 200 SEK, most of which have a large main compartment, none or a few extra pockets, and a shoulder strap. Concerning the aesthetics of the bags in this category, most of them are single colored and the shape is often simple and square. The most prominent difference between the bags in this category and the picnic bags over 200 SEK is that the bags from the more expensive segment are aimed at specific markets, for example hunting and camping (by providing extra functionality). One cooling bag that also stands out is one from Menu that differentiates from other bags by a modern design and a versatile shoulder strap.

The bags that are shaped as baskets are suitable for picnic as they are carried by hand and provide good possibilities for storing food and beverage of different sizes. They all have an aluminum frame and are foldable which make them space efficient when not used. As the baskets are aimed at resembling the feeling of a traditional picnic basket, they might also attract other types of customers than the other models. Many of these bags have a more playful appearance with bright colors.

Didgeridonnas is the brand that dominates the category of cooling bags for beverages, and they offer a range of different insulating products and bags for specific purposes (cans, six packs, wine bottles etc.). Their products are in the more expensive price range (see Appendix IV), and they also differentiate themselves by using unconventional materials for cooling bags such as oil canvas, Australian wool and leather. The other bags in the category of cooling bags for beverages are adapted to contain bag-in-box wine, cans and large bottles.

Market potential and choice of market

The market potential for cooling bags is connected to the yearly volume of sold items, which there is no publicized information on to be found. However, the volume is affected by the rate of growth and the life span of a product (Johanesson et al, 2004), which will only be discussed and not calculated in this project. The rate of growth may be assumed to be stable but not growing, as the product has been available on the market over a long period of time but without many new designs. Furthermore, the technology of cooling and storing food and beverages in a bag has not changed much over the years as it often is based on having an insulating layer of foam, a waterproof material on the inside (often a metalized film) and in some cases additional features for lowering the temperature with ice packs. The variations over time are insignificant compared to other product categories that are more focused on performance and technology and therefore changes more over time.

The life span of a cooling bag is affected by how often it is used and for what purpose. Looking at the Nordic market, the life span of a cooling bag may be longer as the time of the year when picnicking and being outdoors is limited to the summer months. The bag

therefore gets used less during a year compared to in warmer countries. This generalization is however hard to make as the usage is also affected by culture and other circumstances.

In order to develop a competitive cooling bag, a perceptual map was created which compares the 40 cooling bags that were found on the Swedish market. The chart (see figure 17) ranges from Cheap to Exclusive and from Traditional to Modern and shows that there are two distinct gaps. The gaps are marked with red and blue respectively in the perceptual map.

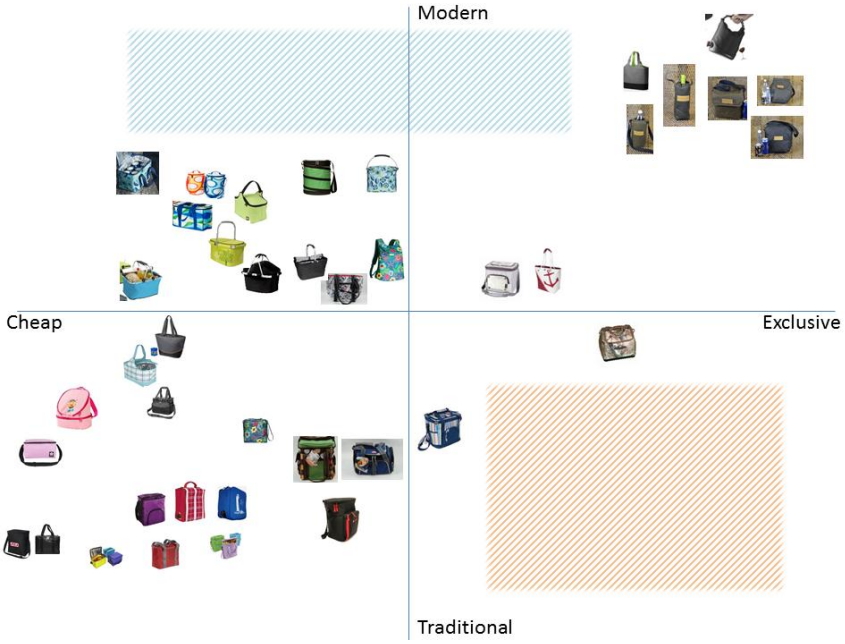


Figure 17. Perceptual map for cooling bags

The red area which covers traditional and exclusive products may be unrepresented since the exclusiveness often is provided with some kind of extra function and technology, and the product therefore also becomes modern. The demand for exclusive cooling bags may also involve a demand for a modern look, as the traditional cooling bag with its simple construction often communicates being relatively cheap. Therefore, this market segment will not be targeted for the product that is to be developed.

The blue area covers products that are modern and ranges from cheap to half exclusive. This segment might be unrepresented since the market for cooling bags is not growing and it therefore is hard for companies to motivate the development of modern and affordable cooling bags. This can be utilized in order to differentiate from the other brands when developing a new bag. The bag that is to be developed will therefore aim at this segment. Furthermore, it will target a younger, urban audience as many of the bags on the market today are of the more traditional type.

Identification of requirements

Wishes are marked with a *, remaining descriptions are identified as requirements.

1. Thermal insulation capability
   1.1 Keep inside temperature under 8°C for 2 hours[3]
2. Comfortable to carry
   2.1 Lightweight
   2.2 Offer various carrying options*
3. Store different types of food and beverages
   3.1 Volume allows PET-bottles (2 L) to be stored*
   3.2 Ability to secure items inside bag*
4. Visually attractive for the intended user group (young adults)
   4.1 In line with current bag and fashion trends*
   4.2 In line with imageboard (see Appedix VI)*
5. Water proof
6. Easy to clean
   6.1 Easy to clean internal area
   6.2 Easy to clean external surface*
7. Safe to contain food and beverages
   7.1 Hygienic
   7.2 Non-toxic materials

Large, soft playing modules for children

User categories

Possible user/customer categories for large playing modules can be divided into households/private persons and organizations. A household is more likely to look for a space efficient set of playing modules than an organization, and the price for the product would have to be lower if it is aimed for a wide audience. Examples of organizations are schools, kinder gardens and playing centers, all of which would purchase a set of playing modules with the intention to use it for creative and fun physical activity for the children. A versatile set which offers possibilities to complement with other sets or modules would be desirable, as it would result in a more long term investment for the organization.

Another categorization that identifies different users is the age of the children of which the products are aimed for. There are differences between how children of different ages play as they are at different levels regarding learning and motor activity. The playing modules may therefore vary in size, weight and level of complexity for the different ages.

Product information & technical solutions

The Swedish market for soft playing modules was scanned through looking at what different retailers and online stores offer. In total, 54 products were found; some of which were large set of modules and others were single pieces. The full list of the products, containing information on price, number of pieces in the set and retailer, can be found in Appendix V. The document also contains information on average prices for sets and per piece. The products were categorized into three categories, namely Large sets of modules ≥ 10 pieces,

[3] Food storage at maximum 8°C prevents bacterial growth in many cases (Livsmedelsverket, 2006). Food at a refrigerator-temperature (6°C) should stay under 8°C when stored in the cooling bag for 2 hours at room temperature.

Small sets of modules < 10 pieces and Animals & other shapes. Below follows a summary of the collected information.

Category	Number of products in category	Average price/piece in category
Large sets of blocks ≥ 10 pieces,	26	722 SEK
Small sets of blocks < 10 pieces	21	1504 SEK
Animals & other shapes	7	946 SEK

Table 3. Categorization of playing modules and average price/piece

The price is however not calculated relatively the size of the playing module, but sets with very small modules were not included as they are not within the aimed product category.

Information on what materials that the soft playing modules are made of is not always stated in the given product information, but most of them are made of high elasticity polyether foam with a washable cover in vinyl or in polyester and/or cotton. All the sets are colorful in their appearance, but it does however differ in what colors they mix. Most of them are in the colors yellow, blue, green and red, but some newer models are offering a more modern palette.

The most commonly found brands for large, soft playing blocks on the Swedish market are Eibe and Wesco, but not all retailers state the brands of the products in their assortment. A majority of the blocks on the market are shaped like squares but often complemented by simple shapes such as arcs, circles, triangles and cylinders in order to create a unique set. The sets form constellations such as slides, tunnels, caves, castles, bridges, stairs and houses. Some pieces that are sold individually are shaped like animals, for example as a dolphin, a frog or a duck. Other single pieces are shaped like for example a cloud, a banana or a bean. Most of these are designed to function as a rocking horse.

The age of the children that the available products are aimed at is not stated for many products, but judging by pictures and available product descriptions the age span can be estimated to 3-10 years old children. This includes children at Swedish "förskola" (nursery school), "förskoleklass" (preschool) and "lågstadium" (early elementary school). Some products are more suitable for younger children (approximately 3-6 years old) as they are stable, lower and consist of simple shapes. Other more complicated sets of modules are clearly aimed at older children of approximately 6-10 years.

Market potential and choice of market

Judging by the presentation and advertisement of available soft building blocks, most seem to be aimed for schools and kindergartens, thus not aimed for private persons. The market for such organizations can be assumed to be larger as not many households have the room that the products require. Furthermore, an organization can use the product for a longer period of time since they have a constant flow of children of specific ages, whilst a family would have a limited time when the child is of an age where the product is fun and interesting. The price aspect thus becomes a determining factor for if a family considers the product to be worth the money as it can only be used for a limited time. However, the products that are sold as individual pieces and functions as rocking horses offer a space efficient and often cheaper solution which could attract households and not just organizations.

The prices of the products that this analysis involves are relatively high, and there are not many options for solutions within a lower price range. Furthermore, it is hard to differentiate most of the brands from each other by the visual appearance of the products, as they are similar in shape and color. This creates an opportunity for the product that is to be developed, as a unique design could differentiate the product from the others. The targeted market segment for this product will be primarily organizations, but by offering constellations of different sizes the product could also be attractive for private persons. The ages of the children that the product is aimed for are 3-6 years, but it could also be used by older children, and it therefore has to offer versatility in how it can be used.

Identification of requirements

Wishes are marked with a *, remaining descriptions are identified as requirements.

1. Encourage creativity and fun
   1.1 Playful appearance*
   1.2 Allow combination of modules
   1.3 Encourage group activities*
   1.4 Encourage physical activity*
   1.5 Encourage mental activity*
   1.6 Allow being carried/moved
2. Weight
   2.1 Light enough to be carried by young children
   2.2 Light enough not to inflict damage on child if tipped from above
   2.3 Heavy enough to provide stability when stacked
3. Safe to interact with
   3.1 Blocks stable on surface
   3.2 No sharp/hard edges
   3.3 Prevent friction burn
   3.4 Hygienic
   3.5 Non-toxic materials
4. Easy to clean*
5. Space efficient when stored*

Lampshade

User categories

There is a wide range of lampshades on the market with different designs and of different prices. The users may be categorised after what they look for in a lamp regarding price, appearance, function and what type of lamp it is; wall, floor, ceiling, desk or window lamp.

Product information & technical solutions

A lampshade is a very visual product with the simple function of providing light and being decorative. The technology it contains is the light source, and it can vary between different types of solutions such as LED, halogen, low-energy bulb or a traditional light bulb. The choice of light source is however in the hands of the user for some models, but is limited by what electrical properties the lamp offers. The lampshade thus has to handle the heat from a light source.

The appearance of lampshades on the market today differs widely, and many are trying to offer modern and attractive designs. A compilation of available models will not be performed for lampshades since the range of products is so wide. No lampshades that are made of soft foam were however found.

Market potential and choice of market

The market potential for an unconventional lamp is promising as there are plenty of unique lamps offered today which represent a wide audience. The aimed market segment is therefore one that represents medium-priced, unique lamps. The final product may be a single lamp of any type or a series of lamps for different purposes. Furthermore, it can if appropriate communicate that it is made from recycled material as this will attract an environmental conscious audience and differentiate the lampshade from its competitors.

Identification of requirements

Wishes are marked with a *, remaining descriptions are identified as requirements.

1. Include interface to light source
2. Visually attractive, in line with imageboard (see Appendix VI)*
3. Safe
   3.1 Hygienic
   3.2 Non-toxic materials
   3.3 No risk of catching fire during use

5.4 Concept development

Screen-walls – Concept descriptions

A morphological matrix was first created from the base of initial ideas; grouping ideas into sub-solutions for various functions of the products. It was then expanded and adapted to involve a wider range of products. This morphological matrix may be found in Appendix VII and was used to generate new and more promising concepts.

A rough screening was then made so that all obvious inferior concepts were removed from the continued evaluation process. Below follows a description of the remaining product concepts.

Combinable base

This concept utilizes a stationary base with multiple standing points with a design that allows screen-walls to be used one by one or combining them into sets of several sections, as illustrated in figure 18. The design of the screen-wall and the base allows each individual section to be adjusted freely, angle wise, if combined with multiple sections.

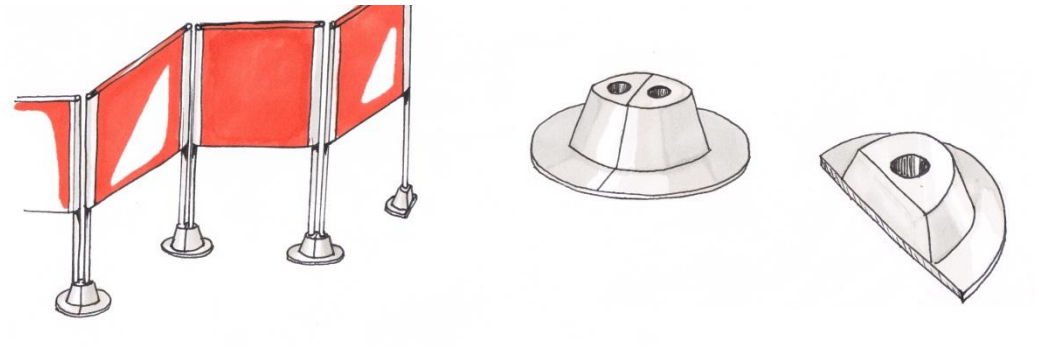


Figure 18. Combinable base concept

The sound absorbing panels are made out of a rebonded PUR-foam board that is fastened to a profile with a hole. These foam boards may be used either as they are (exposing the foam) or by being covered by a fabric that adds protection as well as customizability regarding aesthetics. Rods are fastened to the bases in a vertical position and the panels slide onto the rods through the holes in the profiles. The height of the panels may be adjusted with a locking-ring that is attached to the rods – which is illustrated in figure 19.

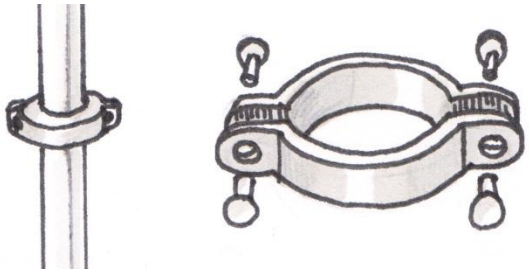


Figure 19. Locking-ring for combinable base concept

Angled base

This concept is the most traditional screen-wall concept as it consists of a sound absorbing panel with a single and simple stationary base. The base is designed so that it is allowed to be placed in close proximity of other screen-walls. As illustrated in figure 20, the design prevents bases of multiple screen-walls from clashing when placed in angles >90°.

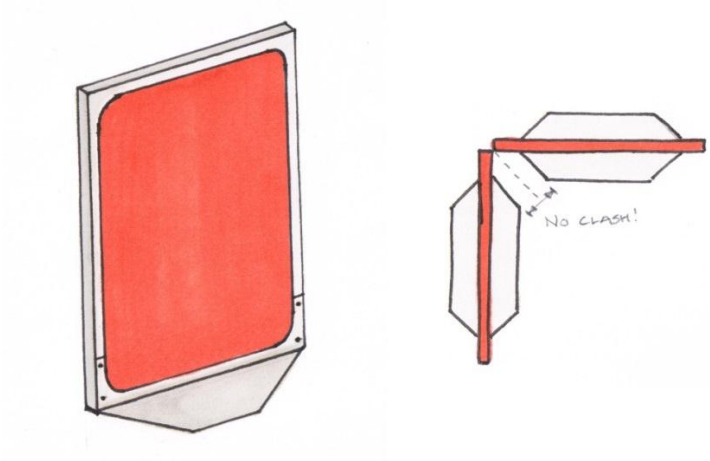


Figure 20. Angled base concept

The panel is made from a board of rebonded PUR foam which is stabilized by a surrounding frame. Alike the previously described concept, this concept's panel may also have a cover. The base is of a thin sheet-like construction that extends outwards flat to the ground surface and has chamfered corners at a 45^{O} angle that provides a 'clash free zone'. The panel is secured to the base with a bolt with hole that goes through the base and framing of the panel. The bolt is locked in place with a pin that goes through the hole on the bolt, preventing the bolt from sliding out of place.

Flexible walls

The panels of this concept are of a thinner nature (in regard to above two) so that it is allowed to be curved depending on placement of the bases. This requires that the bases themselves need to have a high enough weight and friction so that they will not be displaced by the internal forces in the panel when being curved. Additionally, to not being restricted to straight panels, this screen-wall also allows several sections being linked through the bases which are shared between sections – meaning that one screen-wall can be used alone with two bases and if another section is added only one additional base is needed, as one is shared between the two sections. Pipes or profiles are attached to the base and the panels are, similarly to the first concept, slid into place. This is illustrated in figure 22.

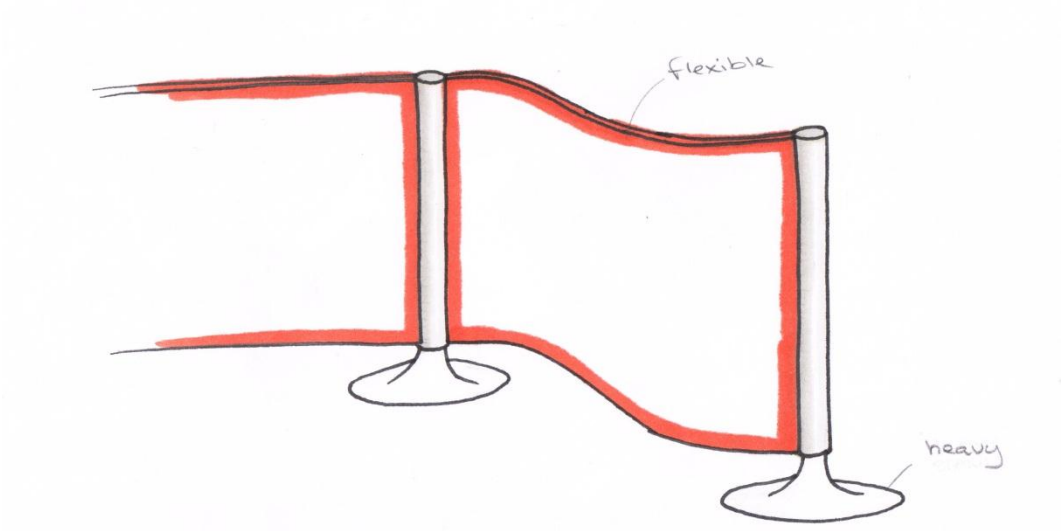


Figure 21. Flexible walls concept

The sound absorbing panel is a sheet of rebonded PUR foam, which is thin enough so that it allows to be curved relatively easy. These sheets are fastened to profiles at each end. Covering these panels is more sensible due to the curving feature, which may make it harder to look aesthetically good or work as intended. However, one idea is that the cover itself can be designed in a fashionable way and be wrinkled in a vertical manner and thus wrinkles are a part of the aesthetics created.

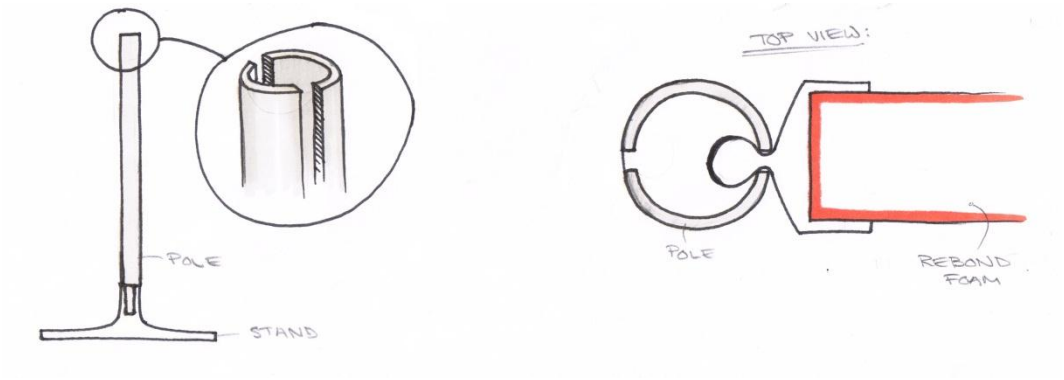


Figure 22. Close-up on profiles for Flexible walls concept

Screen-walls - Evaluation

The three concepts described were evaluated further by establishing a list of criteria, which were used in a Pugh matrix. The Pugh matrix can be found in Appendix VIII. The comparison was iterated in several stages and from the results several conclusions can be identified:

- All three concepts were rated equally in regard to safety
- The Combinable base concept was superior in stability, but inferior in portability/assembly
- The Angled base concept was superior in manufacturability, cost and portability/assembly, but inferior in maintenance, aesthetics, market potential/business opportunity and customizability
- The Flexible walls concept was superior in aesthetics, weight and customizability, but inferior in durability and stability.

The results also showed that the Flexible walls concept was the most promising concept as it was consequently ranked highest in each iteration stage. It shows potential in being improved further; both in regard to strengthen its advantages and diminish its disadvantages. Therefore, the flexible walls concept was chosen to be developed further.

Packaging solutions – Concept descriptions

Regarding concepts for packaging material, this project has not included any extensive concept development. Instead, in this section, you may find documented examples of applications where current packaging solutions of today may be replaced (partly or fully) with recycled PUR foam. For a list of current available solutions, see section 5.3.

Sheets & pads

There are a wide range of common products that are sheets or blocks of various materials; including bubble wrap, cardboard, various papers that are wrinkled, EPS and LDPE. All of these have potential of easily being substituted with rebonded PUR foam, as the rebonded foam is manufactured in large blocks that may be pressed into a wide range of densities (softness) and cut into virtually any dimension desired – from thin sheets that could replace bubble wrap, to smaller blocks that could replace harder more structural cardboard pads.

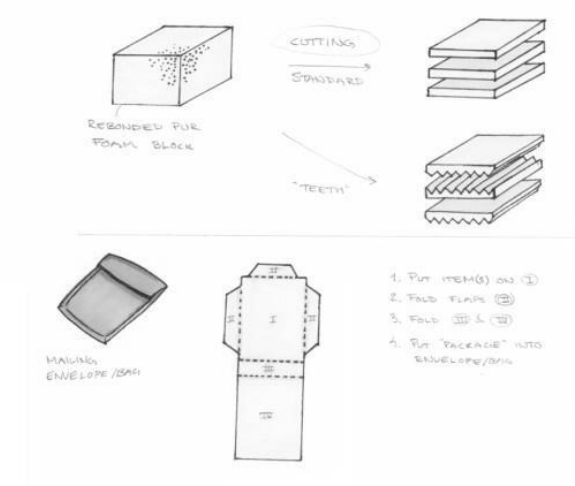


Figure 23. Packaging solutions

Filling

Current solutions that serves as a cushioning filling material, such as chips and wrinkled paper, could easily be substituted with either granulated (shredded) PUR foam or rebonded PUR foam that is chopped up into smaller pieces, for instance small cubes for a more regular and constant filling product.

Packaging solutions - Evaluation

As previously stated, there was no focus on developing new concepts in the product category of packaging solutions. Due to the simplicity and similarities of the examples stated above, no comparable evaluation of the individual ideas was performed. Instead, a more general evaluation is conducted.

By substituting current solutions with recycled PUR foam, either by pre- or post-consumer foam, the need for using other virgin resources for manufacturing packaging material is decreased. It would also result in packaging solutions that are possible to recycle over and over again (by repetitively rebonding) and in the long run make packaging solutions in general consist of fewer types of material. In a long term perspective, this would in return lead to an easier processing procedure for all packaging solutions of PUR foam; both in manufacturing and transportation, as the same material is being used.

Cooling bags – Concept descriptions

The four most promising concepts for cooling bags are focused on either containing cans or to provide a versatile storage for food as well as different types of beverage. By having two products in the same product family, the risk of developing a bag that aims at satisfying all needs at the same time and thus lack a clear target group is lowered. The user will therefore have the possibility to choose the right cooling bag for his/hers needs. The trend of offering cooling bags adapted for specific beverages is followed in the first two concepts, which offers storage of four and six cans respectively. The bags can of course be used to store food in if preferred, but are adapted to provide stability for cans. The two last concepts offer a more versatile and spacious solution adapted for food and bottles. The aim with the four designs is to attract an urban, young adult audience which is communicated through the imageboard (Appendix VI).

Laying cans

This cooling bags offers storage of four cans which are stacked on top of each other. They are easily reached by opening up the buckle at the front of the bag. If only a few cans or something small is stored in the bag, it can be tightened and therefore retain a good cooling capacity as empty space inside the bag would otherwise lead to lowered cooling capacity. The bag has one shoulder strap and is relatively small, which makes it agile to carry.

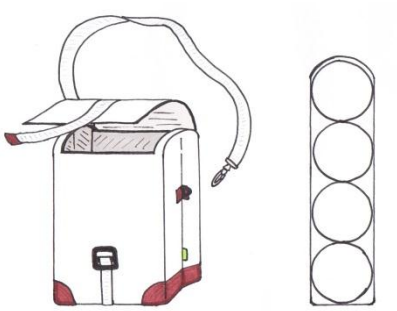


Figure 24. Laying cans concept

Standing cans

In contrary to the previously described concept, this concept is adapted to hold the cans in a standing position. It can contain up to six cans and alike the previous concept; it has a single shoulder strap. The cans are reached by opening the zipper on the front of the bag. The bag is slightly larger than the previous concept which also opens up for a more versatile usage.

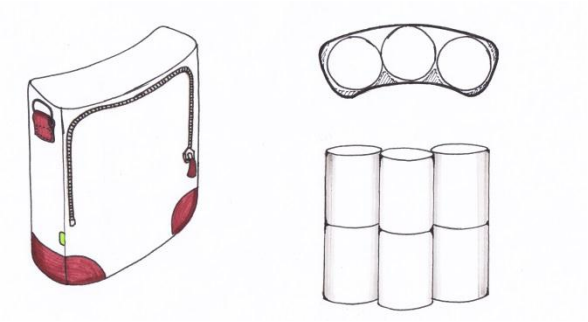


Figure 25. Standing cans concept

Sliding insert

This cooling bag has the same outer construction as the next described concept, but with a different solution for the storage area. The design is inspired by the popular canvas bag with details in leather. It has two shoulder straps which allow it to be carried on one shoulder. The storage area for this concept has two sliding inserts which can be used to create compartments of different sizes (for e.g. wine bottles or boxes of food). The inserts are fastened to the inside of the bag by having a strap along each long side which goes around a piece of durable fabric that is placed on the two large walls inside the bag. The pieces of fabric are detachable at one end by using velcro, thus allowing the user to remove the inserts if needed. The insets are, like the walls of the bag itself, made out of rebonded PUR foam with a cover that easily can be cleaned.

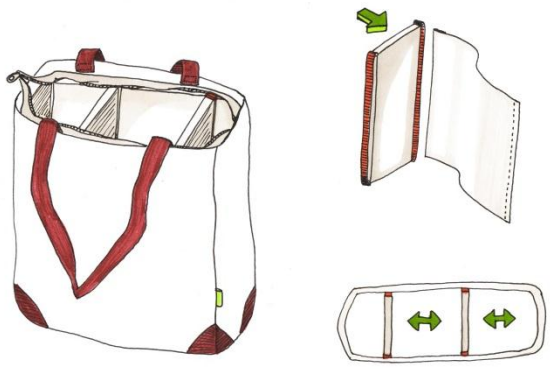


Figure 26. Sliding insert concept

Inserts with velcro

With the same outer construction and design as the previous concept, this concept offers a high level of versatility inside. It has strips of velcro at two levels on the inside of the bag. The velcro strips run along all walls, and make it possible to fasten wall inserts, ice packs or straps to the bag. Wall inserts can be placed to create stable compartments of different sizes and straps can be used for securing specific items and thus prevent them from tipping. Ice packs with velcro on them can be frozen before use and then placed at a location in the bag where an extra low temperature is needed.

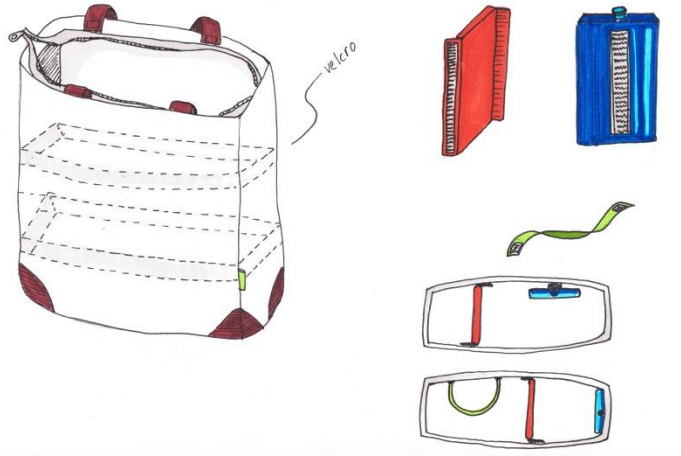


Figure 27. Inserts with velcro

Cooling bags – Evaluation of concepts

The aim of the evaluation was to choose two concepts; one which is adapted to store cans and one with a more versatile storage area suitable for picnics. The four concepts may be described as two versions of two different bags, as they already have a similar design and functionality. They were therefore not compared in a Pugh matrix as it would be dominated by zeroes. The evaluation instead focused on functionality and aesthetics as these were the criteria that differed the most between the concepts.

In summary, the aesthetics of the Standing cans concept was more in line with both the aimed expression communicated through the imageboard as well as with the design of the two other concept for cooling bags, which is important since they will belong to the same product family. The proportions, as a result of the placement of the cans, are also more

appealing for the Standing cans concept compared to the Laying cans concept. The zipper opening further adds a uniqueness that the laying cans concept lacks. The choice of final concept therefore ends at the Standing cans concept.

Regarding the second type of cooling bag there was a bigger difference between the two concepts, even though they have the same exterior design. The concept called Inserts with velcro was judged as having the risk of offering too many possibilities for the user, resulting in a feeling of abundance instead of customizability. Furthermore, there are drawbacks with having removable parts such as the risk of losing them and the risk of them not being used and therefore just occupying storage space. The inserts in the concept called Sliding inserts can if needed easily be moved to one side and stored there instead of being removed completely.

There was also a difference in the expressed quality of the concepts. Velcro is not often associated with modern and trendy products, and therefore affects the exclusiveness and quality feel of the product in a negative way. Furthermore, it may not be desirable to have as much velcro exposed as the concept has in a product that is going to contain food, since it can give associations to camera bags or other very functional oriented products. The Sliding inserts concept on the other hand offers a more discrete solution which is also in line with the exterior of the product. All these arguments contribute to the decision of picking the Sliding inserts concept as one of the final concepts.

Lamps – Concept descriptions

Seven designs for lamps that utilize rebonded PUR foam were evaluated and compared. The aim with the expression of the lamp is communicated through the imageboard in Appendix VI. The concepts are described below.

Disks

This lamp has a glass cylinder with a light bulb inside at the center of the lamp, covered with a framework that holds several layers of disks. The disks are made out of rebonded PUR foam, and are of different radiuses. The lamp is a ceiling lamp and gives more ambient than directional light.

Figure 28. Disk lamp concept

Arcs

The design called Arcs is a versatile solution with a lampshade that easily can be used both as a ceiling lamp and as a floor lamp. It has a simple construction of four bended sheets of rebonded PUR foam that are riveted to a holder. The lampshade can then be fastened to either a floor stand or a hanging cord with a light bulb.

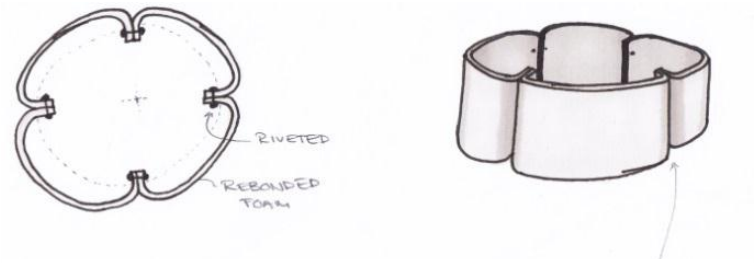


Figure 29. Arcs lamp concept

Office

This lamp is suitable as an office or desk lamp with its directional light. It has a lampshade in rebonded PUR foam which creates a contrast to the rest of the white and metallic parts. The angle of the lamp is adjustable.

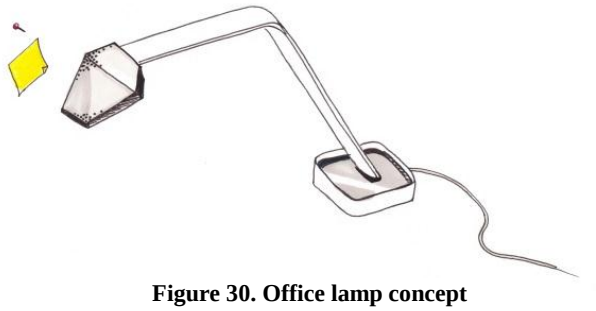


Figure 30. Office lamp concept

Cube and cylinder

The Cube and cylinder concept uses both recycled PUR foam and recycled PVC or EPDM. The cylinder at the top is made from a sheet of rebonded PUR foam which is stitched together at the ends. The base of the lamp is made from recycled PVC or EPDM which enhances the feeling of being made from recycled materials.

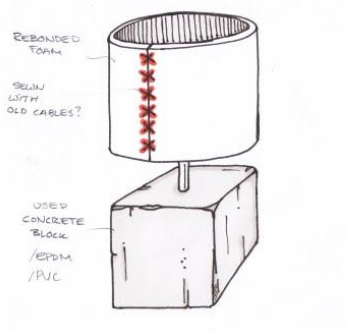


Figure 31.Cube and cylinder lamp concept

Desk

This lamp is intended to light up a desk with its angled sheets of rebonded PUR foam. It has a metal framework, painted in a vibrant color, which provides stability.

Figure 32. Desk lamp concept

Cylinder

The cylinder concept is similar to the Desk concept, but has a cylindrical shape and a circular base. It has a metal framework that provides stability. The lamp is intended to give ambient light, maybe by being placed at a windowsill or at a table.

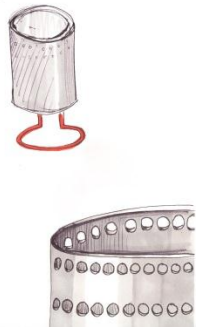


Figure 33. Cylinder lamp concept

Cube

This lamp is a small ceiling lamp that is made out of sheets of rebonded PUR foam. The sheets are sewed together to form a cube without any bottom. The sheets are thick enough to provide stiffness to the cube. A colorful cord with a light bulb is fastened to it.

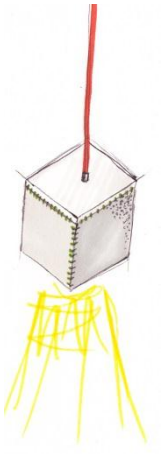


Figure 34. Cube lamp concept

Lamps – Evaluation of concepts

As the product is a very visual product, it was evaluated by foremost using the imageboard complemented by a list of criteria. The list of criteria was used as a checklist and as a basis for discussion instead of a Pugh matrix, since the main focus was the visual aspect of the lamps. The criteria that were considered were price, manufacturability, complexity and modularity. The concept called Arcs was after the evaluation considered being the most promising concept regarding both aesthetics and the mentioned criteria. It has a simple construction, yet looks unique. Furthermore, it is modular in a way that makes it possible to use the lampshade both as a floor lamp and ceiling lamp which opens up for variation. It is also possible to scale it down to create a table lamp within the same product family.

Large, soft playing modules for children – Concept descriptions

Three different concepts for large, soft playing modules were taken to the final evaluation. They are all different but still provide mental and physical activity in a creative way for children at the age of 3-6 years. All modules in all three concepts are made out of rebonded PUR foam with covers of different materials.

Bricks and Sticks

The Bricks and Sticks concept consists of several rectangular modules and long sticks. The modules have holes in them with the same diameter as the sticks, which opens up for a wide range of combination possibilities. The sticks can for example be used to join modules to create walls, which then can be joined in different constellations. The sticks can also be put under a set of modules to create a rolling movement. Obstacle courses can also be created, and the modules can be used as sitting furniture when needed.

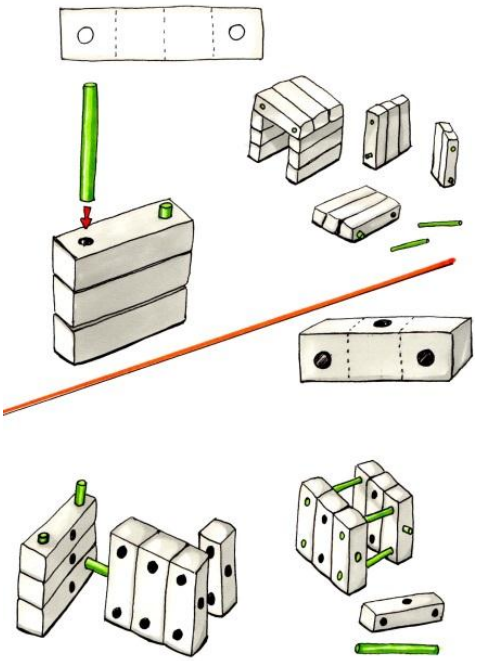


Figure 35. Bricks & sticks concept

Puzzle

The Puzzle concept consists of a set of modules that form a square foundation when put together in the right way. The set can be used as a large puzzle, or to build different constellations. The individual pieces can also be used as sitting furniture. The concept further offers the possibility to integrate letters, numbers or pictures on the sides of the modules to focus even more on learning and mental activity.

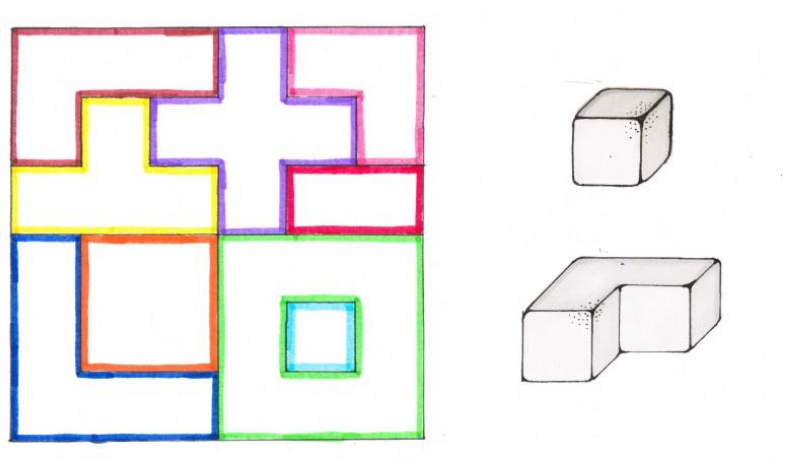


Figure 36. Puzzle concept

Forest

The Forest concept contains soft playing modules of different kinds; animals, log pieces, a bush/crown and stone blocks. The set has a forest theme, and the modules can be used for playing and building. The log pieces and stone blocks can also be used as sitting furniture.

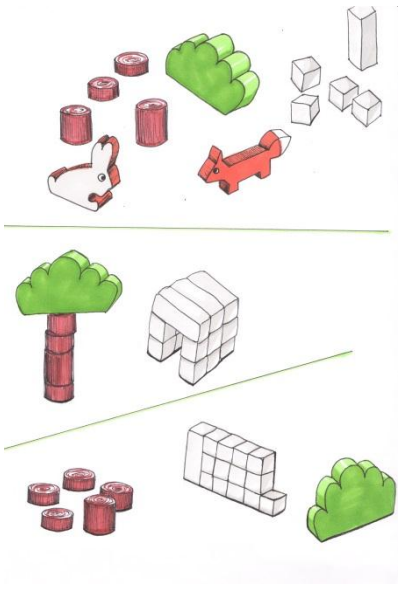


Figure 37. Forest concept

Large, soft playing modules for children – Concept evaluation

Two iterations of a Pugh matrix (Appendix IX) were performed in order to compare the three concepts. All concepts scored equally regarding safety, cost, business opportunity, mental activity and versatility. The Bricks and Sticks concept has the disadvantage of being more complex than the others, with its wholes through the modules, and therefore scored negative on manufacturability, durability and cleaning/maintenance. Furthermore, it does not have the same playful appearance as the other concepts and therefore scored negative on aesthetics. The Forest concept has the advantage of being more playful in its appearance as it contains nature-inspired shapes and modules shaped like animals. The forest theme would also stand out on the market today as most current playing modules are either in a set of geometrical shapes or sold as individual pieces if shaped like animals. However, the Forest concept is not as space efficient as the other concepts when being stored which is a disadvantage.

The ranking according to the results from the Pugh matrices shows that the Puzzle concept is equally good as the Forest concept, and that the Bricks and Sticks concept got the lowest score. As mentioned earlier, the Forest concept has the potential of being more competitive on the market as it offers a solution that is not available today, whilst the Puzzle concept is relatively similar to current products with its geometrical shapes. The Forest concept also opens up for the possibility of offering even more modules on the same theme, thus giving the customer the possibility to combine the modules according to his/hers preferences. Based on these aspects, it was decided to make the Forest concept a final concept.

6. FINAL RESULTS

In this chapter, all final concepts are presented. It includes functional descriptions, scenarios and information on construction, material and manufacturing. Furthermore, it includes commercial assessments and exploration plans as well as recommendations for continuous development. Lastly, the informative poster is presented.

6.1 Presentation of final concepts

exPURiment – Screen-walls

Functional description

The screen-wall concept is a flexible solution aimed towards exhibitioners and other users that are looking for mobility and customizability. The design allows sections of panels being attached to another in a wide range of configurations. The panels are designed so that they may be curved by placing each attachment point (pole) closer to each other, if so desired. This further expands the customizability of the screen-walls; if one would like to create an isolated space or compartment with "rounded corners" – rather than a regular box like space – this is a possibility with this solution.

Figure 38. To the left: one screen-wall section.
To the right: two examples of configurations.

The whole product is easy to assemble and disassemble for simple and space efficient transportation. One section consists of two bases (which stands on the floor), two poles; which goes into each base, and one panel (a foam board with attached profiles on the sides); which is slid onto the poles (through grooves into which the profiles goes).

The screen-walls have a total height of 185 cm and each panel is 100cm wide and 2 cm thick. The total width depends on the number of panels that are attached, which is practically unlimited. Panels are offered in two different sizes; Full Coverage and Half Coverage. The Full Coverage panel has a height of 165 cm and extends from the top (185 cm) down to the top of the base (height: 20 cm from floor), resulting in a small gap (20 cm) in the bottom towards the floor. The Half Coverage panel is half that size; 82,5 cm, and thus' leaves a larger gap towards the floor (102,5 cm). This larger gap may be desired in some situations to create a more open environment, which still offers sound absorption (focusing on the surrounding sounds in height of the human head; mouth and ears)

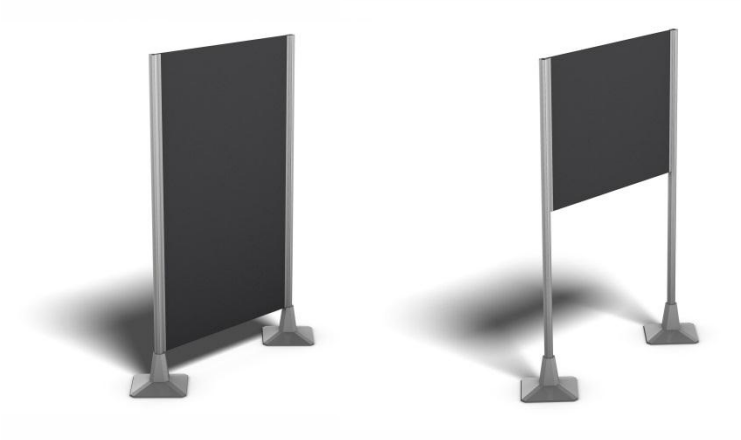


Figure 39. Comparison of Full & Half Coverage

If desired, there are also covers available that may be slid onto the poles in those grooves which are not 'in use' to modify the aesthetics. Covers with half the length of one panel is also used together with the Half Coverage panels to elevate them and create the larger gap towards the floor.

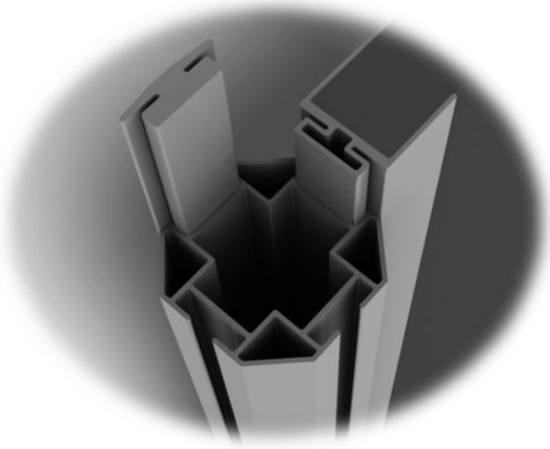


Figure 40. Close-up picture that illustrates how a panel and a cover is slid onto a pole.

Scenario

Bob is working at Innovative Bob's Equipment AB and is to have an exhibition area, at the Industry Innovations Fair 2013. He travels there with two colleagues with a van where they fit all equipment and material for the exhibition; including a set of screen-walls, posters, product catalogues, business cards, a few bar tables and chairs, one of their newest products

in their supply range which they want to promote and a trolley that they use to transport the items from the van to the exhibition area.

The fair opens at 13:00 on a Friday, but they arrive early in the morning so that they have plenty of time setting up their exhibition area. They are a bit tired after the trip, but it is not too bad after some coffee. It is also not a big deal since they do not have that much to prepare; the screen-walls are easy to transport; the poles and covers are relatively light and carried in bags dimensioned for a number of these and the panels and bases are easily stacked and transported on a trolley, and they are also easy to install. The product that they are to display is already assembled in beforehand so it just needs to be transported on the trolley to the booth area along with the rest of the equipment.

It is a big fair with many exhibiting companies and a lot of expected visitors and business partners. Since they are going to be working there the whole Friday and Saturday, they want to use the screen-walls to lower the sound level around primarily themselves, but also their visitors. But they do not want to risk people from missing their 'booth' by closing up the area too much, so they settle with a few screen-walls in each of the corners of their square-like area. They do however expect several potential clients to do business with and want to be able to have private discussions with less background noise, so they also build a small semi-circular/square area within their booth with a small gap to enter through and only a standing table inside where they can stand and do business in serenity.

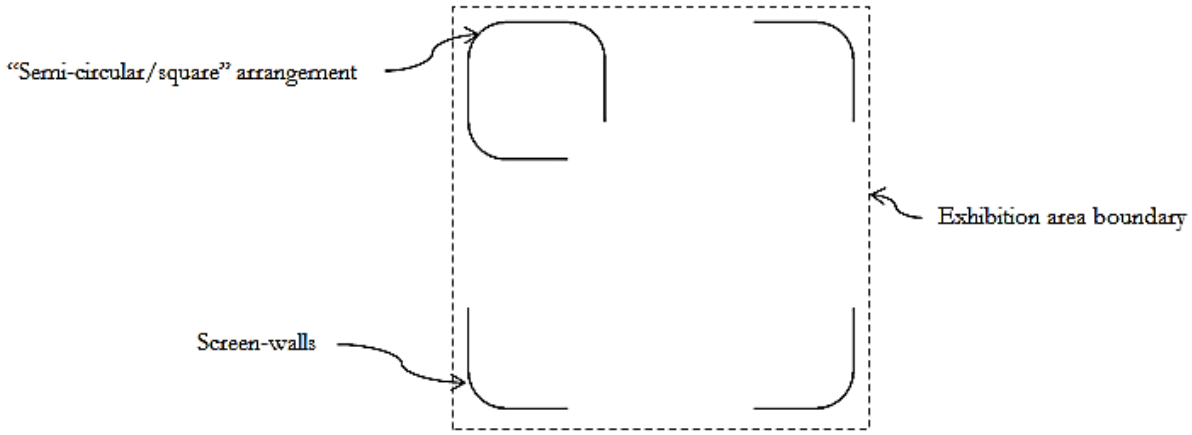


Figure 41. Illustrating the screen-wall setup described in the scenario.

Construction, materials and manufacturing

As previously described, the concept consists of following parts:

Panel:

Involves three components; including the sound absorbing board itself which is cut into correct dimensions from a block of rebonded PUR foam and two extruded profiles made out of aluminum which are attached with adhesive at both sides of the board.

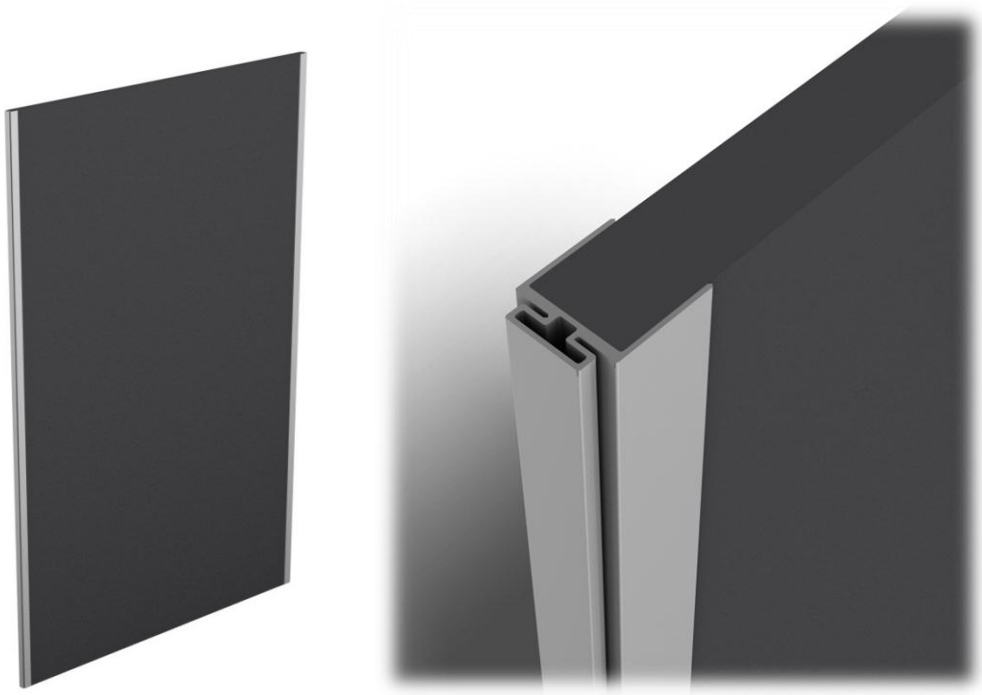


Figure 42. To the left: illustrating the panel.
To the right: illustrating attachment of profiles to foam board

Pole:

Extruded profiles are made out of aluminum. These profiles have four T-shaped grooves which the panels are slid into, and thus', up to four panels may be attached to each pole. These grooves are placed on sides that are perpendicular to each other, as illustrated in the figure below.

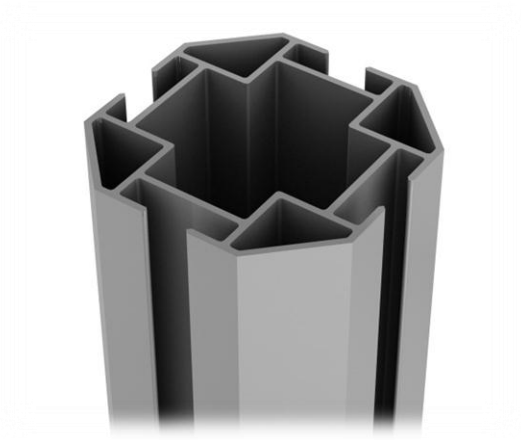


Figure 43. Part of CAD model that illustrates the pole with its four 'T'-grooves.

Base:

The base consists of a shell of either injection molded polymer, preferably recycled and/or recyclable, or aluminum (for a more luxury version) and a heavier insert that gives the base a stability that is needed. This insert could be recycled scrap metal of some sort.

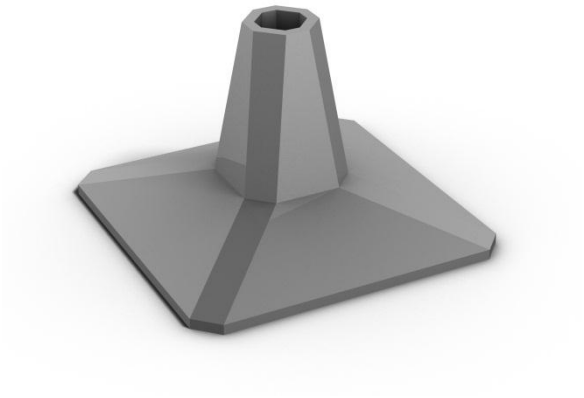


Figure 44. CAD model that illustrates the base.

Profile Cover:

Extruded profiles are made out of either matching polymer used for the base, or aluminum. These have a rim that slides into the grooves of the poles.

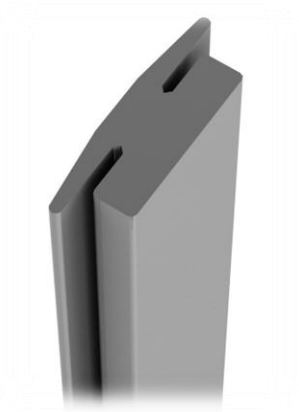


Figure 45. Part of CAD model that illustrates the profile cover.

Commercial assessment and exploration plan

The average market price for single-panel screen-walls is 1'923 SEK (see section 5.3). Although many aspects are unknown for the concept; i.e. whether a standard profile is used or not for the pole and if the profile covers and base (shell) is made out of aluminum or a polymer (and which polymer), the estimated market price for this concept should be able to match the currently available solutions. What further supports this is that there are screen-walls today that use similar constructions with aluminum profiles.

What differentiates this product concept from other currently available products is that it is modular with high customizability, which gives the possibility of being able to have a market price higher than the average.

If the panels use raw rebonded foam, without any exterior cover, there is a need to sanitize the foam (if post-consumer foam is used). However, if a cover would be used, the need for sanitation is less crucial and such costs may be cut down, but then costs are also added for the cover itself (including material costs and processing).

The screen-walls could target both companies that attend exhibitions and fairs at various locations, as well as exhibition centers and companies that offer exhibition and fair spaces and services. These companies could then offer the screen-walls to exhibiting clients that does not want or are able to bring their own equivalent equipment to the fair.

Continuous development and recommendations

The following aspects need to be investigated or performed for the continuous development of the screen-walls:

- All the profiles (poles & covers) should be investigated for standard profiles that already exists and may be used
- Investigate whether profile covers are needed at all by having a pole design with 'good' aesthetics without covers.
- Currently there are no end caps for the poles incorporated in the product. It needs to be investigated whether if such caps are needed and how they would be designed. If such end cap would be used, it is preferably of the same material that the profile covers & base.
- Optimization of all dimensions regarding the sound abosrbing panel; optimal height, width and thickness.
- Specifying materials more in detail and optimization of all dimensions regarding the construction; for satisfactory stability and durability.

temPURature - Cooling bags

Functional description

The cooling bags of temPURature are aimed at a wide target group but especially adapted for a young adult audience in the city. It comes in two different versions; one adapted for beverage cans (to the left in figure 46) and one with a more generous, versatile storage area (to the right in figure 46). The cooling bag adapted for cans is perfect for keeping drinks cold during a hot summer day, an outdoor excursion or picnic in the park. When needed, it can of course be used to store food in as well. It has a simple design with a zipper opening on the front. The second cooling bag has an adaptable storage area with two inserts that can easily be slid back and forth in order to create compartments of different sizes (see figure 47). It therefore provides stability for boxes, bottles, cans, glasses, food containers etc. Furthermore, it allows the food to be tightly packed and therefore keep it at a low temperature for longer. The inserts can be removed if needed, or just slid to the inner end of the bag where they occupy less space.

Figure 46. Illustration of cooling bags

Figure 47. Close-up on inside of cooling bag

Scenario

Olivia is one her way home from the university, and is looking forward to a picnic in the big park with her friends. It is late May and the sun is shining. She arrives home to prepare some sandwiches and a salad. When finished, she puts the food in her cooling bag. The compartments are easy to adapt for the food containers which she finds satisfying. She also packs the bottle of lemonade that she made yesterday in the bag. The bottle is made of glass but she easily secures it at the end of the bag with the sliding inserts. She closes the bag and leaves on her bicycle, heading for the big city park with the cooling bag hanging on the handlebar. Her friends are already there when she arrives and Anna, her best friend, has brought a whole bag with cool drinks for everyone. She kept them cold and safe in her temPURature cooling bag, which is of the same brand as Olivia's bag. They bought them at the same day a month ago, since they found them both functional and appealing in their designs. They also like the environmental aspect of them being made from recycled material.

The friends all enjoy a long picnic in the park together, with the noise of seagulls and football playing kids in the background. If you ask Olivia, there is no better way to spend the afternoon on a day like this.

Construction, materials and manufacturing

Both bags utilize the same materials, which makes the production more cost efficient. They have an outer shell of organic cotton canvas. The insulating layer is made from rebonded PUR foam that has been cut into thin sheets. Between the cotton canvas and the foam, there is a layer of polymeric film (e.g. PVC, polyester or EVA) which protects the foam from moisture and makes it possible to clean the outer cotton canvas with a damp cloth when needed. The inside of the bag is covered with a metallized film which separates the food from the foam. The metallized film is also easy to clean, water resistant and safe to store food in. Both bags are closed with a zipper.

The bottom of the bag is the part that is exposed to most tear and dirt, and it therefore is covered in a protective leather imitation material. This further strengthens the aesthetics of the bag and makes it more durable. The bag is sewed together and the inserts for the temPURature bag are assembled afterwards.

Commercial assessment and exploration plan

An estimated marketing price for the cooling bags is around 300 SEK/bag. This is higher than average since most cooling bags cost less than 200 SEK (see section 5.3), but it is still a suitable price for the aimed target group. The price for rebonded foam, as stated in the pre-study, is 17,1-25,7 SEK/kg. Through comparison with the price for polyethylene foam, which is commonly used in cooling bags today, it becomes clear that there is not much of a difference; the price for low density polyethylene foam is 19,2-20,6 SEK/kg (CES Edupack, 2012). Other material costs that are equal to current cooling bags are the inner metalized film and the polymeric film. The organic cotton canvas and the details in leather imitations are however extra accessories that increases the costs. The cooling bags could utilize both pre- and post-consumer foam, but would require sanitation to a decent level of the post-consumer foam, since it is product which is going to contain food.

With advertisement aimed at the intended audience, the brand of temPURature has the potential to reach far. Music festivals as well as sports and culture events offer the

opportunity to market the product and get the brand noticed and recognized. Furthermore, the recycling aspect is an asset for the brand and could thus be used in marketing.

Compared to the other available cooling bags, the temPURature cooling bags stand out as they are more similar to normal bags. This makes them further suitable and attractive to carry in social situations. The main competitors are Menu and Didgeridoonas, as they are also offering modern designs, some of which are adapted for specific beverages. Their prices are however higher which further differentiates the temPURature cooling bags from its competitors. The bag's unique solution with the sliding insert also contributes to its competitiveness.

Continuous development and recommendations

The following aspects need to be investigated or performed for the continuous development of the cooling bags:

- Optimize the material choice for all fabrics/films to minimize environmental stress and optimize EOL treatment
- Develop the detail design to ensure time and cost efficient manufacturing (sewing etc.) of the product
- Gather data on user needs and requirements to ensure that the bags dimensions are adapted for the most common type of picnic food and beverages
- Create a plan for optimization of logistics and distribution
- Create a detailed marketing and commercialization plan to reach successful sales

LightMe – Lamps

Functional description

The lamp of LightMe comes in two versions; a floor lamp with a red metal frame and a roof lamp with a red cord. Both lamps use the same lampshade, which is made from rebonded PUR foam. A light bulb is placed in the center of the lampshade, and the lamp provides an ambient light suitable in a modern home environment.

Figure 48. Visualization of lamp in two versions

Scenario

Michael has just arrived home from work. It has been a stressful day at the office, and he is happy to arrive at his apartment just outside the city center. He walks around the apartment to turn all the lights on. It is December and he appreciates all the light he can get this time of the year. He has one lamp in particular, placed in the corner of his livingroom, which he is really fond of. It has a lampshade made from recycled foam, and Michael enjoys the feeling of having a unique lamp. It works as a piece of art in the room, and when he has new friends over they always stop and look at the lamp for a few extra seconds, trying to resist the temptation of touching its soft surface. It certainly draws attention to itself, but without taking much visual attention.

Construction, materials and manufacturing

The lampshade is created from four thin sheets of rebonded PUR foam that are riveted to an inner metal construction (see figure 49). They are slightly bended and together they form a soft, round shape. The metal construction is the interface to the frame or cord, depending on what version of the lamp it concerns. The rebonded foam is made from pre-consumer foam as it has high requirements on the mixture of colors, to achieve a consistent look for all lamps produced. The mixture of colors might however vary over time but is still within the range of dark grey shades with a few pieces of foam in bright colors. This mixture works well aesthetically with the red frame and cord.

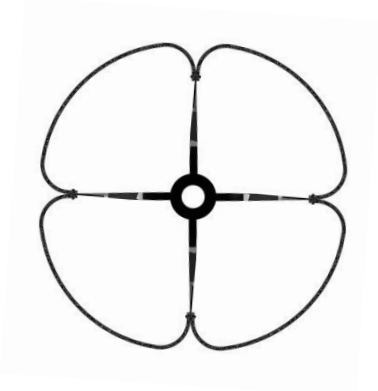


Figure 49. Top view of the lampshade

Commercial assessment and exploration plan

The competitors for the lamp are many, and a strong brand would therefore be beneficial to have behind it. The brand of LightMe could involve more interior products on the same recycling theme. Materials can be used in new ways in these products, thus questioning our norms and expectations on them. Marketing through different interior magazines could be a good way to introduce the product.

The simple construction makes the lamp cost efficient to manufacture. It is also an advantage to have the lampshade and inner construction as common parts between the two versions.

Continuous development and recommendations

The following aspects need to be investigated or performed for the continuous development of the lamp:

- Perform test on how the rebonded foam ages over time when it is exposed in an home environment
- Investigate if the frame can be made from recycled material, thus strengthening the recycling aspect of the brand
- Create a plan for optimization of logistics and distribution (especially important if the foam is collected from several manufacturers)
- Create a detailed marketing and commercialization plan to reach successful sales

PURe fun - Large, soft playing modules

Functional description

The large, soft playing modules called "PURe fun" are designed for children of the ages 3-6 years. They are mainly aimed at nursery schools and pre-schools but can also be used in a home environment. They offer a versatile usage as they can be used for playing, building, learning and as sitting furniture. They can also be used to practice motor skills, such as balance and coordination, or be used as an obstacle course. Figure 50 and 51 show the modules in two different situations together with silhouettes of users (children).

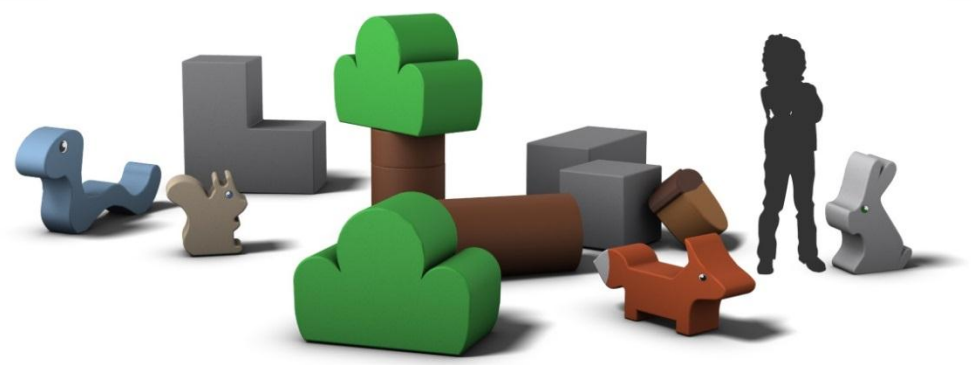


Figure 50. Setup example 1

Figure 51. Setup example 2

The set has a forest theme and consists of the following modules:

Stones:

The stones are available in different shapes created from the basic shape of a cube. They encourage children to build caves and other constellations, involving physical activity in a creative way.

Logs, bushes and acorn:

The logs and bushes can be combined to form trees of different heights, depending on the ages of the children. The log pieces and the acorn can be used to sit on when doing other activities.

Animals:

The animals in the set are a rabbit, a fox, a squirrel and a worm. They are meant to spur the creativity and imagination of the children and therefore open up for a range of different ways to play and have fun with.

Scenario

Simon is a nursery school teacher and has been working with children for nine years. He recently took the initiative to purchase a set of large, soft playing modules for the children at the school, which has been very appreciated both by the children and the staff. It fascinates Simon that the children continuously find new ways to play with the set. He further enjoys seeing how the older children can play together with the younger children and how they inspire each other. Of course it was a bit chaotic when the set of modules arrived and all children wanted to play at the same time, trying out and exploring all of the modules. But now it has become a calm and fun part of the day when the children are allowed to use the set. Simon and his colleagues sometimes also use it as sitting furniture or to screen of the surroundings during the morning gathering with the children.

Construction, materials and manufacturing

The modules consist of rebonded PUR foam with a cover in polyester and cotton blend fabric. The fabric is soft which contributes to a more inviting and cuddly product compared to modules with a vinyl cover. The polyester complements the cotton well with higher durability and wrinkle-resistance. The cover can easily be removed and washed since it has a zipper opening.

The rebonded foam is manufactured in large blocks and then cut to the shapes of the different modules. The generated waste from cutting can be ground and once again rebonded, thus becoming a part of another playing module.

Commercial assessment and exploration plan

The price for one playing module should not be higher than the average price for individually sold pieces, which is 946 SEK as calculated in the market analysis. The L-shaped stone module, which is one of the biggest modules, has a volume of ~0,2 m^2. If the density is set to be 60 kg/m^3 for the rebonded PUR foam (which is the lowest possible value in the range of density for the material, as stated in section 4.2), the weight of the module is ~12 kg. The price for rebonded PUR foam is 2-3 €/ kg, and counting with the higher value, the price for the foam for the L-shaped stone module is ~36 € (approximately 310 SEK). The

costs for fabric and sewing of the cover will also add to this, as well as costs for the cutting process of the rebonded foam blocks. There is however room for these costs without exceeding a reasonable profit margin.

The theme of the set and the possibility to combine different kinds of modules clearly differentiates PURe fun from competitors. The fact that it is made from recycled material can be used to the product's advantage by being a part of the brand. The playing modules can be made from either pre- or post-consumer waste, with the pre-consumer waste being the cheaper alternative. However, if strongly implementing the recycling aspect in the brand identity it could motivate that the product is made from post-consumer foam even though it requires more labor, equipment and time due to separation and sanitation.

The most efficient way to reach out to schools with the soft playing modules would be by having large retailers selling the products. This would also mean that the products are exposed in product catalogues and in web-shops. Private persons are also possible customers, but will not provide higher sales than organizations concerning the price of the products and how much space they occupy in a home. It could however still be valuable to reach out to these and have the products available for ordering. The marketing towards private persons can be done through ads in magazines and on webpages as well as at exhibitions and fairs.

Continuous development and recommendations

The following aspects need to be investigated or performed for the continuous development of the large, soft playing modules:

- Optimize shapes of modules for minimum waste from cutting
- Optimize shapes of modules for easy removal of fabric cover
- Make prototypes with different densities of the rebonded foam to investigate how they behave
- Perform observation studies by introducing the set of playing modules to children; this would render understanding of how it can be improved from a user perspective
- Gather data on how potential customers at schools perceive the products
- Create a detailed marketing and commercialization plan to reach successful sales

6.2 Common aspects of costs and logistics

A critical factor of the cost aspect is how large the yearly market is for each product and thus the production volumes. The production volumes should be in line with the available volumes of foam waste. If the amounts of foam waste do not cover the demand, there is a risk of not having the product available and therefore losing potential income. However, a waste flow should not be encouraged to increase and it is therefore important to make sure that the amounts of available foam waste match the need for it. The opposite situation of only being able to handle some of the foam waste is of course not desirable either. What also makes the situation more complex is that the waste flow is not constant but will change over time depending on the companies that generate the waste (when dealing with pre-consumer foam).

Logistics is another critical aspect, affected by the availability of the foam waste and where it is located. The pre-consumer foam would be more cost efficient to use, even though there is a bigger need for recycling of post-consumer foam. It would be desirable to achieve local solutions at the sites where the waste is generated. Concerning post-consumer foam, the implementation of EPR could make it possible for companies to take responsibility of the products after the use phase. Separation, sanitation and quality assurance will of course add to the cost of producing new products of the recycled material.

6.3 Informative poster

The informative poster gives and overview of the recycling possibilities of soft PUR foam. It is suitable for educational usage as it quickly communicates important aspects of the subject. The format of it is three merged (portrait) A2 sections.

The first section gives an introduction to why the subject of recycling PUR foam is important and what material group PUR is. It further presents a breakdown structure of pre- and post-consumer foam and possible EOL treatments. The recycling methods of rebonding, regrinding and chemolysis are presented at the bottom of the first section.

The second section focuses on the opportunities given by rebonded PUR foam. It contains a short description of the market, the material's properties and information on prices and costs. It also explains the difference and commonalities in characteristics of rebonded foam made from pre- and post-consumer foam.

At the bottom of the second section, an introduction to the third section may be found which guides the reader/viewer to the concluding part of the poster; the presentation of possible areas of applications and presentation of product concepts. The possible areas of application are presented in a breakdown structure and are divided into categories according to what property they utilize. Below follows an overview of the poster and close-ups on each section.

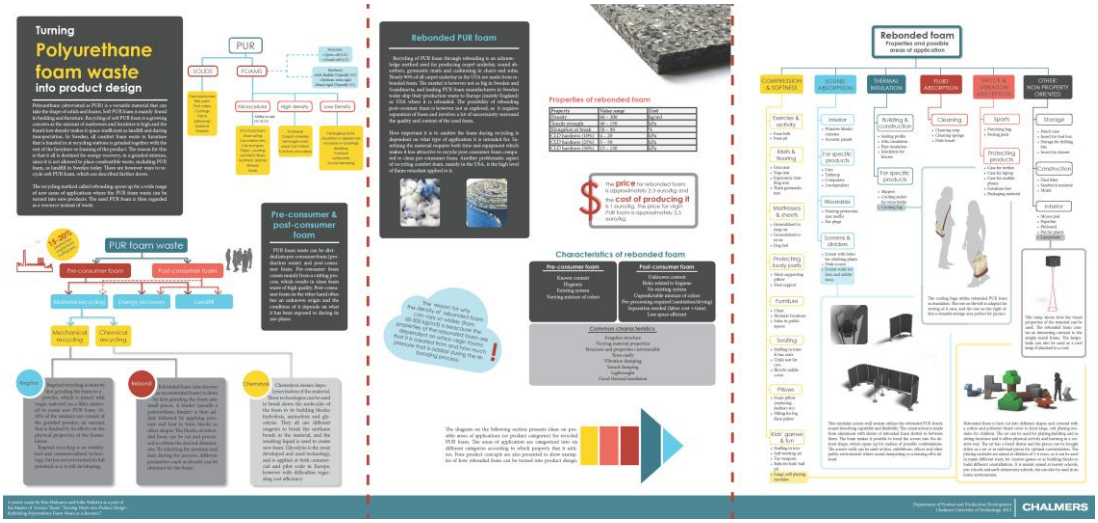
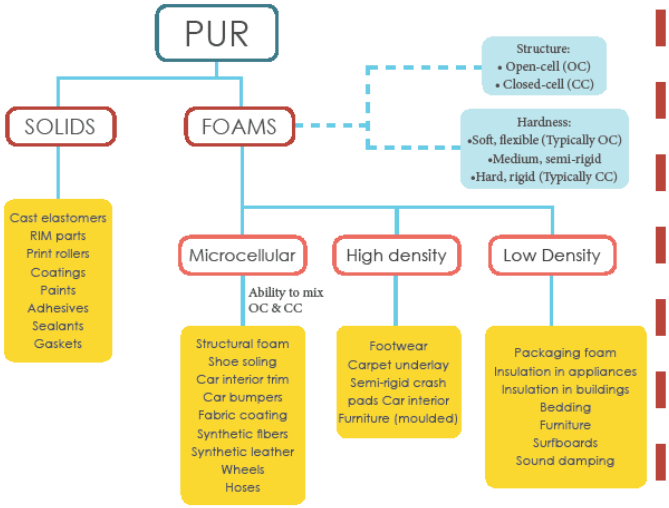


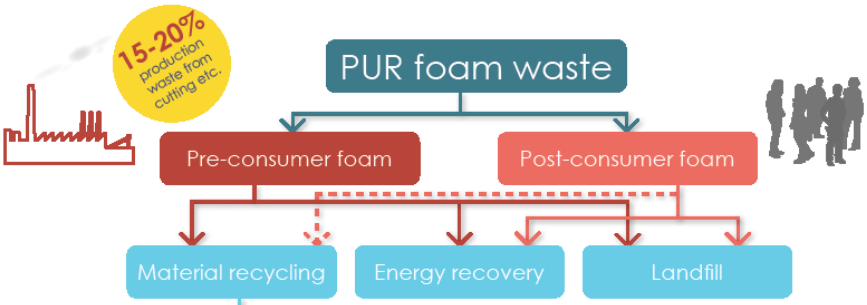
Figure 52. Overview of poster

Turning
Polyurethane foam waste
into product design

Polyurethane (abreviated as PUR) is a versatile material that can take the shape of solids and foams. Soft PUR foam is mainly found in bedding and furniture. Recycling of soft PUR foam is a growing concern as the amount of mattresses and furniture is high and the foam's low density makes it space-inefficient as landfill and during transportation. In Sweden, all comfort foam waste in furniture that is handed in at recycling stations is grinded together with the rest of the furniture or framing of the product. The reason for this is that it all is destined for energy recovery, in a grinded mixture, since it is not allowed to place combustible waste, including PUR foam, as landfill in Sweden today. There are however ways to recycle soft PUR foam, which are described further down.

The recycling method called rebonding opens up for a wide range of new areas of applications where the PUR foam waste can be turned into new products. The used PUR foam is then regarded as a resource instead of waste.





Pre-consumer & post-consumer foam

PUR foam waste can be divided into pre-consumer foam (production waste) and post-consumer foam. Pre-consumer foam comes mainly from a cutting process, which results in clean foam waste of high quality. Post-consumer foam on the other hand often has an unknown origin and the condition of it depends on what it has been exposed to during its use-phase.

Regrind

Regrind recycling is done by first grinding the foam to a powder, which is mixed with virgin material (as a filler material) to create new PUR foam. 10-20% of the mixture can consist of the grinded powder; an amount that is limited by its effects on the physical properties of the formulation.

Regrind recycling is an established and commercialized technology, but has not yet reached its full potential as it is still developing.

Rebond

Rebonded foam (also known as reconstituted foam) is done by first grinding the foam into small pieces. A binder (usually a polyurethane binder) is then added, followed by applying pressure and heat to form blocks or other shapes. The blocks of rebonded foam can be cut and processed to obtain the desired dimensions. By adjusting the pressure and heat during the process, different parameters such as density can be obtained for the foam.

Chemolysis

Chemolysis means depolymerization of the material. Three technologies can be used to break down the molecules of the foam to its building blocks; hydrolysis, aminolysis and glycolysis. They all use different reagents to break the urethane bonds in the material, and the resulting liquid is used to create new foam. Glycolysis is the most developed and used technology, and is applied at both commercial and pilot scale in Europe, however with difficulties regarding cost efficiency.

A poster made by Kim Niskanen and Sofia Wallsten as a part of the Master of Science Thesis "*Turning Waste into Product Design - Rethinking Polyurethane Foam Waste as a Resource*".

Rebonded PUR foam

Recycling of PUR foam through rebonding is an acknowledge method used for producing carpet underlay, sound absorbers, gymnastic matts and cushioning in chairs and sofas. Nearly 90% of all carpet underlay in the USA are made from rebonded foam. The market is however not as big in Sweden and Scandinavia, and leading PUR foam manufacturers in Sweden today ship their production waste to Europe (mainly England) or USA where it is rebonded. The possibility of rebonding post-cosumer foam is however not as explored, as it requires separation of foam and involves a lot of uncertainity surround the quality and content of the used foam.

How important it is to sanities the foam during recycling is dependent on what type of application it is intended for. Sanitizing the material requires both time and equipment which makes it less attractive to recycle post-consumer foam compared to clean pre-consumer foam. Another problematic aspect of recycling comfort foam, mainly in the USA, is the high level of flame retardant applied to it.

Properties of rebonded foam

Property	*Value range*	*Unit*
Density	60 – 300	kg/m3
Tensile strength	40 – 150	kPa
Elongation at break	50 – 90	%
CLD hardness (10%)	4 – 20	kPa
CLD hardness (25%)	5 – 50	kPa
CLD hardness (50%)	15 – 150	kPa

The **price** for rebonded foam is approximately 2-3 euro/kg and the **cost of producing it** is 1 euro/kg. The price for virgin PUR foam is approximately 2,5 euro/kg.

The reason for why the density of rebonded foam can vary so widely (from 60-300 kg/m3) is beacause the properties of the rebonded foam are dependent on which virgin foams that it is created from and how much pressure that is added during the re-bonding process. !

Characteristics of rebonded foam

Pre-consumer foam

Known content
Hygienic
Existing system
Varying mixture of colors

Post-consumer foam

Unknown content
Risks related to hygiene
No existing system
Unpredictable mixture of colors
Pre-processing required (sanitation/drying)
Separation needed (labor cost + time)
Less space efficient

Common characteristics

Irregular structure
Varying material properties
Structure and properties customizable
Tears easily
Vibration damping
Sound damping
Lightweight
Good thermal insulation

The diagram on the following section presents ideas on possible areas of applications (or product categories) for recycled PUR foam. The areas of application are categorized into six different categories according to which property that it utilizes. Four product concepts are also presented to show examples of how rebonded foam can be turned into product design.

Rebonded foam
Properties and possible areas of application

COMPRESSION & SOFTNESS

Exercise & activity
- Foam balls
- Foam pit

Mats & flooring
- Gym mat
- Yoga mat
- Ergonomic standing mat
- Thick gymnastic mat

Mattresses & sheets
- Groundsheet to sleep on
- Groundsheet to sit on
- Dog bed

Protecting body parts
- Neck-supporting pillow
- Heel support

Furniture
- Chair
- Modular furniture
- Sofas in public spaces

Seating
- Stuffing in tram & bus seats
- Child seat for cars
- Bicycle saddle cover

Pillows
- Foam pillow (replacing feathers etc)
- Filling for big floor pillow

Kids' games & fun
- Stuffing in toys
- Soft bowling set
- Toy weapons
- Balls for kids' ball pit
- Large, soft playing modules

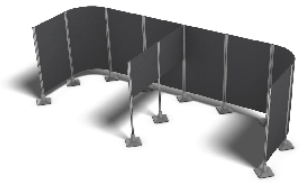
SOUND ABSORPTION

Interior
- Window blinds/ curtains
- Acoustic panels

For specific products
- Cars
- Tabletop
- Computers
- Loudspeakers

Wearable
- Hearing protection (ear muffs)
- Ear plugs

Screens & dividers
- Screen with holes for climbing plants
- Desk screen
- Screen-walls for fairs and exhibitions



This modular screen-wall system utilizes the rebonded PUR foam's sound absorbing capability and flexibility. The construction is made from aluminum with sheets of rebonded foam slotted in between them. The foam makes it possible to bend the screen into the desired shape, which opens up for endless of possible combinations. The screen-walls can be used at fairs, exhibitions, offices and other public environment where sound dampening or screening off is desired.

THERMAL INSULATION

Building & construction
- Sealing profile
- Attic insulation
- Pipe insulation
- Insulation for houses

For specific products
- Slippers
- Cooling jacket for wine bottle
- Cooling bag

The cooling bags utilize rebonded PUR foam as insulation. The one on the left is adapted for storing of 6 cans, and the one on the right offers a versatile storage area perfect for picnics.

FLUID ABSORPTION

Cleaning
- Cleaning mop
- Cleaning sponge
- Dish-brush

SHOCK & VIBRATION ABSORPTION

Sports
- Punching bag
- Boxing pads

Protecting products
- Case for bottles
- Case for laptop
- Case for mobile phone
- Furniture feet
- Packaging material

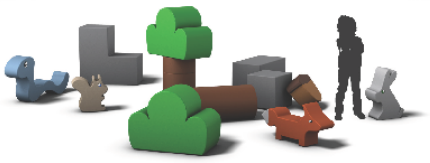
OTHER: NON PROPERTY ORIENTED

Storage
- Pencil case
- Insert for tool box
- Storage for drilling bits
- Insert for drawer

Construction
- Dust filter
- Sandwich material
- Molds

Interior
- Mouse pad
- Paperbin
- Pinboard
- Pot for plants
- Lampshade

This lamp shows how the visual properties of the material can be used. The rebonded foam creates an interesting contrast to the simple metal frame. The lampshade can also be used as a roof lamp if attached to a cord.



Rebonded foam is here cut into different shapes and covered with a cotton and polyester blend cover to form large, soft playing modules for children. The set can be used for playing,building and as sitting furniture and it offers physical activity and learning in a creative way. The set has a forest theme and the pieces can be bought either as a set or as indiviual pieces for optimal customization. The playing modules are aimed at children of 3-6 years, as it can be used in many different ways; for creative games or as building blocks to build different constallations. It is mainly aimed at nursey schools, pre-schools and early elementary schools, but can also be used in an home environment.

7. DISCUSSION

The deliverables and findings of the project show that the possibilities offered by soft, flexible PUR foam when it comes to recycling are many. There are, however, uncertainties surrounding the possibility of recycling post-consumer foam and what costs that it would involve. Furthermore, no information has been available regarding quantities of available resources and obtaining this information would have been valuable in order to verify the benefits of the results.

In projects like this, where you start with a given material rather than an existing market demand/need, there are uncertainties in the initial phase regarding which types of products that are to be developed. Therefore, the pre-study had to be carried out in an explorative way involving large amounts of information. If a focus or limitation would have been set at the start of the project (e.g. through a need from a company/organization/user), the pre-study could have been more concentrated and only relevant information would have been gathered. Furthermore, by having a shorter and more focused pre-study the process of developing product concepts could have been given more time, thus involving a more thorough developing and evaluation process.

The creative phase of the project gave a wide range of ideas, which was satisfying. The way in which the workshop was carried out, with a relaxed and creative environment and with provided stimulus, gave valuable input to the ideation. It would have been very time consuming to generate the same amount of ideas without external input. The process of screening the ideas showed to be more of a challenge that the actual generation. The screening required knowledge within a wide range of areas in order to give each idea an equal chance and not missing out on possibilities due to lack of knowledge. External input could have been helpful to make this process more efficient and provide more expertise for the decision making. At the same time, the decisions needed to be taken rather quickly to allow the project to enter the product development phase and not to get stuck in the screening phase.

The balance of identifying the most promising ideas and at the same time dedicate enough time for it to be developed to a desirable level was challenging. To be able to do this, the standpoint was to evaluate concepts adequately so that the concepts that finally were chosen belong to the group of most promising concepts – rather than to necessarily identify and develop the ultimate concepts.

The decision of developing several concepts and not just one was taken with respect to the aim of the project, as it was to show the possibilities given by the material and not just one possible way to close the loop for it. This also affected how far the concepts were able to be developed. The limitation of the development showed to be challenging as there were several steps in the product development process that could have been added or performed in more detail if the timeframe would have allowed it.

The poster proved to be an efficient way to summarize the most important findings of the project. Since the pre-study showed that information about the material and its recycling possibilities was both scattered and hard to find, it further motivated the creation of the poster as it can be used in educational purposes.

Lastly, an interesting aspect is that the concepts developed in this project could very well be considered as commercially competitive products independently whether they utilize recycled material or not. The strength behind this lies in that they have been developed based on a thorough market analysis, including analysis of currently available solutions.

8. CONCLUSIONS

The polymeric material of soft flexible polyurethane (PUR) foam is possible to recycle through chemical or mechanical recycling. Mechanical recycling, or more specifically rebonding, is the most suitable method to focus on when it comes to product development and how it can be used to get the material back into the market. This is due to the fact that it is the most acknowledged method today and other available methods focus on either using the material as a filler material or breaking it down to its raw constituents to create new "virgin" material.

The product concepts that were developed serve as good examples of how recycled PUR foam can be beneficially utilized for competitive products with a commercial value. Furthermore, the concepts show a diversity of possibilities, representing how the material's properties can be beneficially utilized in a product.

Several possibilities of closing the gap between disposal and manufacturing of new products, for flexible PUR foam, have been identified. The material offers a wide range of properties that are beneficial to utilize in various applications, such as: compression & softness, sound absorption, thermal insulation, fluid absorption and shock & vibration absorption. The pre-consumer foam waste is today often exported, which opens up for the possibility to instead use this waste as a resource locally; i.e. creating products that could be manufactured and sold within the country where the waste is generated. By extending the life of the material (especially concerning post-consumer foam) and using it in various applications or replacing other materials with it, the need for producing other virgin material could be decreased, thus decreasing the use of natural resources.

There are difficulties that still need to be dealt with in order to ensure that the developed concepts are realizable and economical beneficial if introduced on the market. These difficulties involves uncertainties regarding available amounts of foam waste (both pre- and post-consumer), costs related to pre-processing post-consumer foam and to what extent the post-consumer foam can be sanitized. Furthermore, the aspect of logistics is essential to solve in order to create a sustainable and economically viable business case.

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Feet on grass: http://www.gettyimages.se/detail/foto/woman-standing-barefoot-on-grass-low-angle-view-bildbank/888241-001
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Cotton:
http://about.hm.com/content/dam/hm/about/images/en/Editorial%20images/Top%20images/cotton.jpg/_jcr_content/renditions/cq5dam.web.648.486.png
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Texture 2: http://img0.etsystatic.com/000/0/5365078/il_fullxfull.62217692.jpg
Texture 3: http://www.noctua-graphics.de/images/download/tex/metal/metbgr01.jpg
Texture 4:
http://fc03.deviantart.net/fs8/i/2005/319/0/d/Wood_Texture_Stock_by_digital_amphetamine.jpg
Texture 5: http://www.gettyimages.se/detail/foto/knot-knitted-background-royaltyfri-bild/166048536

Imageboard - lamp

Plants breaking through pavement: http://www.gettyimages.se/detail/foto/green-grass-which-grew-from-concrete-bildbank/114043219
Rustic house: http://www.trendir.com/house-design/rustic-cabin-designs-1.jpg
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Thread: http://www.gettyimages.se/detail/foto/twine-cone-royaltyfri-bild/143221925
Plant: http://www.gettyimages.se/detail/foto/saxifrage-in-rusty-tin-can-container-selective-focus-close-up-bildbank/73771172
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Texture 5: http://www.ropeandsplice.co.uk/images/natural-hemp-rope.jpg

APPENDIX I - LIST OF GENERATED IDEAS

SOUND ABSORPTION	THERMAL INSULATION
Interior	**Building and construction**
Decoration/statues	Below foundation of houses
Window blinds/curtains	Insulation material in other countries
Canvases and picture frames	Sealing profile
Acoustic panels (with or without print)	Replacing heavy insulation material
For specific products	Attic insulation
Cars	Pipe insulation
Panels in computer case	Insulation for passive houses
Computer case	**For specific products**
Heels	Oven mitts
Tunnels	Slippers
Loudspeakers	Cooling bag
Tabletop (sheet attached underneath)	Protective cover for cars during winter
Wearable	Trivet (underlay for cooking vessels)
Hearing protection (muffs)	Cooling jacket for wine
Ear plugs	
Screens and dividers	
Screen	
Desk screen with built in lamp	
"a room within a room"	
Booth for fairs	
Foldable screen-wall for exhibition/fairs	
Screen with holes for climbing plants	

FLUID ABSORPTION	SHOCK & VIBRATION ABSORPTION
Cleaning	**Protecting individuals**
Shower sponge	Shock absorbing carpet below cars
Cleaning mop	Foldable helmet
Cleaning sponge	Compressed as airbag
Cleaning cloth	Protection against mines
Preventing disasters/accidents	**Protecting products**
Absorbing water in floods	Table leg protective cover
Condensation protection when overclocking PCs with liquid nitrogen	Protection cube for fragile devices/products
Absorbing oil at oil spills	Protections for tools
Water reservoir during dry seasons	Packing material
Water bank	Case for bottles
Using in aquaponds	Case for laptop
Replacing soil (for plants)	Case for mobile phones
Water reservoir in soil	Case for electronics
Random	Case for glasses
"Essence sponge" (sponge with oil that smells)	Furniture feet
Use in oil tanks when transporting (preventing flow movement)	Padding envelopes
	Case for music instruments
	Sports
	Punching bag
	Boxing pads

OTHER - NON-PROPERTY-ORIENTED	OTHER - NON-PROPERTY-ORIENTED, CONTIN.
General and unspecified	**Combustion**
Construction material	Pellets/briquettes
Replacing wood	**Storage**
Buoyancy	Cable storage (foam piece with holes)
Buoy	Bag
Floating accessory for keys	Pencil case
Accessories	Packaging bag in bookstore or similar
Frame for glasses	Insert for tool box
Hat	Storage for drilling bits
Necklace	Storage for knitting needles (just punch through)
Bracelet	Insert for drawer/shelf
Shoulder pads	**Construction**
Interior (found in homes)	Dust filter
Mouse pad	Air filter
Toilet brush	Sandwich material
Lampshade	Molds
Paperbin	Road cone
Fruit bowl	**Random**
Pinboard	Frisbee
Decorative clock	Ball that detonates mines
Pot for plants	
Door stopper	

COMPRESSION & SOFTNESS	COMPRESSION & SOFTNESS, CONTIN.
Exercise and activity	**Kids' games and fun**
Non-lethal ammo for games (replacing paintball)	Large foam hands
Exercise equipment	Stuffing in toys
Foam balls	Pet toys
Foam pit	Soft bowling set
Fat-suit	Toy weapons
Stress ball	Large puzzle pieces
Mats and flooring	Soft hammers
Dampening in floors	Balls for kids' ball pit
Flooring for playgrounds	Large blocks to play with
Jujitsu mats	**Furniture**
Gym mat	Stool/chair
Door mat	Bench with metal insert
Carpet inlay for staircase	Modular furniture
Bathroom mat	Sofas in public spaces
Outdoor mat	**Seating**
Yoga mat	Stuffing in tram & bus seats
Ergonomic standing mat	Child seat for cars
Thick gymnastic mat	Soft bicycle saddle cover
Wall-to-wall carpet (in Sweden)	**Pillows**
Mattresses and sheets	Power-nap pillow
Outdoor sitting pad	Hugging pillow
Groundsheet to sleep on	Foam pillow (replacing feathers etc)
Groundsheet to sit on	Filling for big floor pillow
Mattresses for prison beds	**Military**
Mattresses for detox cells	Pressure nullifier to prevent detonation of mines
Dog beds	Vacuum packed PUR bombs that expand on impact
Protecting body parts	**Random**
Knee-protection	Shoe soles
Lining for climbing harness, shoes or pants	Toe separator
Cushioning for handle (bike or tool)	Padding for ironing board
Neck-supporting pillow	Sanding block
Heel support	Road bump
Cushioning handle for plastic bags	

APPENDIX II - PRODUCT INFORMATION AND TECHNICAL SOLUTIONS FOR SCREEN-WALLS

	Retailer	Product name	Art. #	Price (SEK)	VAT	Description
Single-panel types:						
Stationary base:	Gerdmans.se	Utställningsskärmar - single, fötter	601 219	1 437,50	incl.	Screenwall with 1 panel, stationary base
	Gerdmans.se	Skärmvägg texil Event, width: 800mm	513 53-25	2 687,50	incl.	Screenwall with 1 textile surfaced panel, stationary base
	Gerdmans.se	Skärmvägg texil Event, width: 1000mm	513 68-25	2 862,50	incl.	Screenwall with 1 textile surfaced panel, stationary base
	Gerdmans.se	Skärmvägg texil Event, width: 1200mm	513 54-25	3 187,50	incl.	Screenwall with 1 textile surfaced panel, stationary base
	Ojega.se	Utställningsskärm, height: 1600mm	51250-22	1 115,00	excl.	Screenwall with 1 panel, stationary base, width: 950mm
	Ojega.se	Utställningsskärm, height: 1800mm	51251-22	1 325,00	excl.	Screenwall with 1 panel, stationary base, width: 950mm
Base with wheels:	Gerdmans.se	Utställningsskärmar - single, hjul	601 220	1 737,50	incl.	Screenwall with 1 panel, base with wheels
	Ojega.se	Utställningsskärm med hjul, height: 1600mm	51260-22	1 275,00	excl.	Screenwall with 1 panel, base with wheels (w. brakes), width: 950mm
	Ojega.se	Utställningsskärm med hjul, height: 1800mm	51261-22	1 360,00	excl.	Screenwall with 1 panel, base with wheels (w. brakes), width: 950mm
	Ojega.se	Höjdjusterbar utställningsskärm med hjul	64600-24	1 115,00	excl.	Screenwall with 1 panel w. adjustable height (1513-1648mm), base with wheels (w. brakes), width: 770mm
	Mattonbutiken.se	2be skärmvägg singel	674236	1 500,00	incl.	Screenwall with 1 panel, base with wheels (w. brakes), width: 770mm, adjustable height: 1513mm or 1648mm
			Total:	21 150,00		
			Quantity	11,00		
			Average:	1 922,73		

	Retailer	Product name	Art. #	Price (SEK)	VAT	Description
Multi-panel types:						
Stationary base:	Gerdmans.se	Utställningsskärmar - single, fötter	601 222	5 212,50	incl.	Screenwall with 3 swingable panels, stationary base
	Ojega.se	Tredelad utställningsskärm, height: 1600mm	51252-22	2 590	excl.	Screenwall with 3 swingable panels, stationary base, width: 3x950mm
	Ojega.se	Tredelad utställningsskärm, height: 1800mm	51253-22	3 325	excl.	Screenwall with 3 swingable panels, stationary base, width: 3x950mm
	Madema.se	Skärmvägg, 5-delad	18534	5 550	incl.	Screenwall with 5 swingable panels, stationary base, weight: 9,5kg, width: 259cm, height: 165cm
	Madema.se	Skärmvägg, 4-delad	18532	4 850	incl.	Screenwall with 4 swingable panels, stationary base, weight: 7,6kg, width: 204cm, height: 165cm
	Madema.se	Skärmvägg, 3-delad	18531	3 750	incl.	Screenwall with 3 swingable panels, stationary base, weight: 5,7kg, width: 156cm, height: 165cm
	Madema.se	Skärmvägg, 2-delad	18530	2 595	incl.	Screenwall with 2 swingable panels, stationary base, weight: 3,8kg, width: 101cm, height: 165cm
	Mattonbutiken.se	Utställningsskärm i wellkartong, 3-delad	675496-S9124579	1 120	incl.	Package of 5 screenwalls with 3 swingable panels, stationary base, width: 3x72cm, height: 180cm
	Mattonbutiken.se	Utställningsskärm i wellkartong, 4-delad	675497-UTS4	1 850	incl.	Package of 3 screenwalls with 4 swingable panels, stationary base, weight: 3kg, width: 4x90cm, height: 190cm
	Kalls.se	Skärmvägg	129798	4 709	incl.	Screenwall with 3 swingable panels, stationary base, width: 285cm, height: 180cm

	Retailer	Product name	Art. #	Price (SEK)	VAT	Description
Base with wheels:	Gerdmans.se	Utställningsskärmar - 3-pack, hjul	601 221	4 312,50	incl.	Screenwall with 3 swingable panels, base with wheels
	Ojega.se	Tredelad utställningsskärm med hjul, height: 1600mm	51262-22	3 340,00	excl.	Screenwall with 3 swingable panels, base with wheels (w. brakes), width: 3x950mm
	Ojega.se	Tredelad utställningsskärm med hjul, height: 1800mm	51263-22	3 595,00	excl.	Screenwall with 3 swingable panels, base with wheels (w. brakes), width: 3x950mm
	Ojega.se	Höjdjusterbar utställningsskärm med hjul	64610-24	2 790,00	excl.	Screenwall with 3 swingable panels w. adjustable height (1513-1648mm), base with wheels (w. brakes), width: 3x770mm
	Ojega.se	Mobil tredelad utställningsskärm med hjul	941400-24	2 295,00	excl.	Screenwall with 3 swingable panels, base with wheels, height: 1600mm, width: 2400mm
	Silentia.se	Silentia Screen trolley	6514	2 660,00	excl.	Required trolley that is used together with appertained Silentia Folding screen (see below), height: 145cm
	Silentia.se	Silentia Screen trolley	6520	2 890,00	excl.	Required trolley that is used together with appertained Silentia Folding screen (see below), height: 185cm
	Silentia.se	Silentia Folding screen, Colored, 5	6105	3 210,00	excl.	Folding screen with 5 panels, base with wheels, width: 125cm, height: 145cm
	Silentia.se	Silentia Folding screen, Colored, 5	6305	4 160,00	excl.	Folding screen with 5 panels, base with wheels, width: 125cm, height: 185cm
	Silentia.se	Silentia Folding screen, Colored, 7	6107	4 350,00	excl.	Folding screen with 7 panels, base with wheels, width: 175cm, height: 145cm
	Silentia.se	Silentia Folding screen, Colored, 7	6307	5 490,00	excl.	Folding screen with 7 panels, base with wheels, width: 175cm, height: 185cm

Retailer	Product name	Art. #	Price (SEK)	VAT	Description
Silentia.se	Silentia Folding screen, Colored, 9	6109	5 260,00	excl.	Folding screen with 9 panels, base with wheels, width: 225cm, height: 145cm
Silentia.se	Silentia Folding screen, Colored, 9	6309	6 540,00	excl.	Folding screen with 9 panels, base with wheels, width: 225cm, height: 185cm
Silentia.se	Silentia Folding screen, Colored, 11	6111	6 190,00	excl.	Folding screen with 11 panels, base with wheels, width: 275cm, height: 145cm
Silentia.se	Silentia Folding screen, Colored, 11	6311	7 750,00	excl.	Folding screen with 11 panels, base with wheels, width: 275cm, height: 185cm
Silentia.se	Silentia Folding screen, Colored, 13	6113	7 560,00	excl.	Folding screen with 13 panels, base with wheels, width: 325cm, height: 145cm
Silentia.se	Silentia Folding screen, Colored, 13	6313	9 450,00	excl.	Folding screen with 13 panels, base with wheels, width: 325cm, height: 185cm
Silentia.se	Silentia Folding screen, Colored, 15	6115	9 050,00	excl.	Folding screen with 15 panels, base with wheels, width: 375cm, height: 145cm
Silentia.se	Silentia Folding screen, Colored, 15	6315	11 210,00	excl.	Folding screen with 13 panels, base with wheels, width: 375cm, height: 185cm
Silentia.se	Silentia Bed end screen, 1,5m	6522	4 330,00	excl.	Screenwall with 3 swingable panels, base with wheels, width: 150cm, height: 155cm
Silentia.se	Silentia Bed end screen, 1,5m	6523	5 580,00	excl.	Screenwall with 3 swingable panels, base with wheels, width: 150cm, height: 185cm
Silentia.se	Silentia Bed end screen, 2,0m	6525	7 460,00	excl.	Screenwall with 3 swingable panels, base with wheels, width: 200cm, height: 155cm
Silentia.se	Silentia Bed end screen, 2,0m	6526	8 900,00	excl.	Screenwall with 3 swingable panels, base with wheels, width: 200cm, height: 185cm
Madema.se	Skärmvägg, 5-delad med hjul	18534-1	5 750,00	incl.	Screenwall with 5 swingable panels, base with wheels, weight: 9,5kg, width: 259cm, height: 165cm
Madema.se	Skärmvägg, 3-delad med hjul	18531-1	3 950,00	incl.	Screenwall with 3 swingable panels, base with wheels, weight: 5,7kg, width: 156cm, height: 165cm

Retailer	Product name	Art. #	Price (SEK)	VAT	Description
Mattonbutiken.se	2be skärmvägg trippel	674237	4 100	incl.	Screenwall with 3 swingable panels, base with wheels (w. brakes), width: 2280cm, adjustable height: 1513mm or 1648mm
Burema.se	Skärmvägg	7120283	2 493,75	incl.	Screenwall with 3 swingable panels, base with wheels, width: 2270mm, height: 1640mm
Kalls.se	Skärmvägg	129799	5 863	incl.	Screenwall with 3 swingable panels, base with wheels, width: 265cm, height: 180cm
		Total:	211637		
		Quantity:	36,00		
		Average:	5 878,81		

Appendix III - PRODUCT INFORMATION AND TECHNICAL SOLUTIONS FOR PACKAGING MATERIAL

i. Envelopes/bags with cushioning:

Posten "Cushioned envelopes"
Paper envelope with a thin interior layer of bubblewrap i. The envelope is sealed by "peel & seal"-technique by removing a paper strip, exposing a string of glue which secures to a flap of paper.
Available in various sizes; ranging from a size of
210x145 mm with a price of 30 SEK (including postage) to
430x300 mm with a price of 85 SEK.
http://www.posten.se/sv/Sidor/iframes/ebutiken/Butiken-forpackningar-med-porto.aspx

Packoplock "Skumplastpåse" (foam bag)
(Kraft-) Paper bag with a thin interior layer of plastic foam. The bag is sealed by "peel & seal" technique and/or bag rivets.
Available in various sizes; ranging from a size of
95x165 mm with a price of 225 SEK for 200 pieces (= 1,125 SEK/piece) to
345x470 mm with a price of 329 SEK for 50 pieces (= 6,58 SEK/piece).
http://www.packoplock.se/dept/--Skumplast---foliepasar_56795/SWE/SEK

Packoplock "Cushioned bag"
A multi-layered paper bag with a soft paper interior layer and a strong and wear resistant external layer. Interior layer is made from 100% recycled paper and the whole bag is recyclable. It is intended for hard, sharp and fragile products. Sealed by clamps or tape, also available with "peel & seal"
Available in various sizes; ranging from
110x200mm with a price of 443 SEK for 250 pieces (= 1,772 SEK/piece) to
340x470mm with a price of 392 for 50 pieces (= 7,84 SEK/piece).
http://www.packoplock.se/dept/--Vadderade-pasar_51199/SWE/SEK

Arofol "Luftbubbelpåse" (Bubble wrap bag)
(Kraft-) Paper bag (in white or brown) with a interior layer of bubble wrap. The envelope is sealed by by removing a paper strip, exposing a string of glue which secures to a flap of paper.
Available in various sizes; ranging from a size of
100x165 mm with a price of 150 SEK for 200 pieces (= 0,75 SEK/piece) to
350x470mm with a price of 329 SEK for 50 pieces (= 5,18 SEK/piece).
http://www.packoplock.se/dept/--Luftbubbelpasar_51200/SWE/SEK

Arofol "Luftbubbelpåse med tryck – röda band" (Bubble wrap bag with print – red ribbons)
The same bag as the standard Arofol bag, but with red ribbons printed on the bag to give a more elegant look.
Available in two sizes:
180x265 mm with a price of 415 SEK for 100 pieces (= 4,15 SEK/piece)
230x340 mm with a price of 559 SEK for 100 pieces (= 5,59 SEK/piece)
http://www.packoplock.se/dept/--Luftbubbelpasar_51200/SWE/SEK

Arofol "Poly" Luftbubbelpåse" (Plastic bubble wrap bag)
Tear resistant and water repellent white bag of polyethylene with a interior layer of bubble wrap. The envelope is sealed by removing a strip, exposing a string of glue which secures to a flap.
Available in various sizes; ranging from a size of
120x215 mm with a price of 415 SEK for 200 pieces (= 2,075 SEK/piece) to

350x470mm with a price of 334 SEK for 50 pieces (= 6,68 SEK/piece).
http://www.packoplock.se/dept/--Luftbubbelpasar_51200/SWE/SEK

Arofol "Safe" Security bag
The same bag as Arofol Poly, but with "tamper-resistant seal" that indicates/shows warning in event of illegal entry.
Available in two sizes:
180x265 mm with a price of 399 SEK for 100 pieces (= 3,99 SEK/piece)
230x340 mm with a price of 499 SEK for 100 pieces (= 4,99 SEK/piece)
http://www.packoplock.se/dept/--Luftbubbelpasar_51200/SWE/SEK

Packoplock "Luftbubbelpåse Dubbel" (Double layered bubble wrap bag)
(Kraft-) Paper bag with two interior layers of plastic foam. The bag is sealed by removing a strip, exposing a string of glue which secures to a flap.
Available in various sizes; ranging from a size of
140x210 mm with a price of 219 SEK for 50 pieces (= 4,28 SEK/piece) to
340x465mm with a price of 367 SEK for 25 pieces (= 14,68 SEK/piece).
http://www.packoplock.se/dept/--Luftbubbelpasar_51200/SWE/SEK

Packoplock "Matallic bubbelpåse" (Metallic bubble bag)
A metal foil bag with internal layer of bubble wrap. The bag is sealed by "peel & seal" technique. It is intended for advertising purposes or gifts.
Available in various colors and sizes; ranging from
165x156 mm with a price of 589 SEK for 100 pieces (= 5,89 SEK/piece) to
230x324 mm with a price of 1062 SEK for 100 pieces (= 10,62 SEK/piece).
http://www.packoplock.se/dept/--Luftbubbelpasar_51200/SWE/SEK

ii. Insulation material:

Packoplock "Frigolit box"
Lightweight insulating boxes molded out of EPS (expanded polystyrene). Closed with an EPS lid and sealed through wrapping in plastic film or put into a box (which could be made out of cardboard or wood).
Available in various sizes;
140x100x200 mm (2,8 l) with a price of 33 SEK,
170x170x180 mm (5,2 l) with a price of 86,50 SEK,
290x200x120 mm (6,95 l) with a price of 49 SEK.
http://www.packoplock.se/dept/--Isolerboxar_84525/SWE/SEK

"EPS Europalådor" (Euro boxes)
Lightweight insulationg boxes molded out of EPS (expanded polystyrene). Closed with an separately sold EPS lid. Adapted for EU pellets and available in two sizes:
560x360x135 mm (28 l) with a price of 65 SEK.
560x360x235 mm (28 l) with a price of 75 SEK.
Supplemented lid with a cost of 33 SEK.
http://www.packoplock.se/dept/--Isolerboxar_84525/SWE/SEK

CoolKeeper Cooling bags
A formable, sealed, bag of gel which can be heated, cooled and frozen. It is toxin free and recyclable.
Size: 165x140x31 mm. Weight: 450 g. Cost: 22 SEK.
http://www.packoplock.se/dept/--Isolerboxar_84525/SWE/SEK

iii. Cushioning/filling

Alta Cell "packing chips"
Small chips made from recycled polystyrene. Low density material that consists of 99,6% air.
Available in 500 L bags that weights 2,1kg with a price of 369 SEK.
http://www.packoplock.se/dept/--Forpackningschips_51197/SWE/SEK

Cell-Aire "foamed sheets"
Sheets of foamed polyethylene that is low weight, water proof and has shock absorbing capability.
Sold in rolls and available with anti-static properties (about 45% price increment per m^2) .
Available in sheets on rolls in various thicknesses, widths and lengths; ranging from
1 mm thickness, 0,3 m width and 300 m length with a price of 1220 SEK for 5 rolls (= 244 SEK/roll or 2,71 SEK/m^2) to
2 mm thickness, 1,5 m width and 150 m length with a price of 1219 SEK for 1 roll (= 5,42 SEK/m^2).
http://www.packoplock.se/dept/--Skumplast--Cell-Aire_51196/SWE/SEK

Packoplock "Bubble foil"
LD-polyethylene foil with cell structure containing air which is both water proof and insulating. It is also recyclable and available variants with anti-static properties.
Available with various bubble diameters/thicknesses, widths and lengths; foils with a bubble diameter of 10 mm has 4,2 mm thickness and are available in 100 m rolls with widths ranging from 0,3 m with a price of 645 SEK for 5 rolls (= 129 SEK/roll or 4,3 SEK/m^2) to
1,5 m with a price of 599 SEK/roll (= 3,99 SEK/m^2).

Foils with a bubble diameter of 30 mm has 12,7 mm thickness and are available in 50 m rolls with widths ranging from
0,3 m with a price of 670 SEK for 5 rolls (= 134/ SEK/roll or 8,93 SEK/m^2) to
1,0 m with a price of 461 SEK/roll (= 9,22 SEK/m^2).

Anti-static foil is available with a bubble diameter of 10 mm (12,7 mm thickness) and are available in 150 m rolls with widths ranging from
0,5 m with a price of 2175 SEK for 3 rolls (= 725/ SEK/roll or 9,66 SEK/m^2) to
1,0 m with a price of 1425 SEK/roll (= 9,5 SEK/m^2).
http://www.packoplock.se/dept/--Bubbelfolie_51195/SWE/SEK

PaperPlus paper
Single layered (kraft-) papers that are "converted" to multilayered sheets so that small amount of paper takes up larger volumes. It is claimed that one package corresponds to "five to six sacks of filling chips".
A package of 11,6 kg (375x640 mm, 50 g sheets) costs 459 SEK.

The processing of the paper is performed by an electric, foot pedal-operated, machine called PaperPlus Shooter which processes 150 meters/min. This machine may be rented to a monthly fee of 299 SEK.
http://www.packoplock.se/dept/--Pappersskrynklare_58497/SWE/SEK

Fillpak paper
Single layered papers that are wrinkled randomly so that it take up more space than being organized flat. It is claimed that one package corresponds to up to "three sacks of filling chips".
A package of 10 kg (381x500 mm, 50g sheets) costs 499 SEK.
The process of wrinkling may be assisted with the manually operated Fillpak "paper wrinkler" which costs 1050 SEK.
http://www.packoplock.se/dept/--Pappersskrynklare_58497/SWE/SEK

Corrugated paper "Enkelwell"
A strong and formable paper used for wrapping items with uneven shapes or sharp corners.
The sheets are 2,5 mm thick and have a weight of 140 g/m^2.
Sold in 75 m rolls in widths ranging from 10 cm with a price of 33 SEK to 200 cm with a price of 645 SEK.
http://www.packoplock.se/dept/--Enkelwell_51198/SWE/SEK

Corrugated paper "Bigwell"
A reinforced variant of "Enkelwell". Suited for covers and separation layers when moving stuff or transporting. The sheets are 2,5mm and have a weight of 160 g/m^2.
Sold in 75 m rolls in widths ranging from 70 cm with a price of 259 SEK to 120 cm with a price of 399 SEK.
http://www.packoplock.se/dept/--Enkelwell_51198/SWE/SEK

Silk paper
Very thin sheets of paper which are wrinkled and used for small and fragile products such as glas and porcelain. Available in various sizes and densities; example is a pack of 4350 pieces of 45x60 cm sheets with a weight of 17 g that costs 545 SEK.
http://www.packoplock.se/dept/--Silkespapper--guldomslag_51245/SWE/SEK

Waste paper
Thin paper (basically unprinted paper used for news paper) which are wrinkled and used for dampening and protection.
Available in packages of 500 sheets ranging from
43x61 cm (5,9 kg) for a price of 99 SEK to
70x100 cm (15,7 kg) for a price of 259 SEK.
http://www.packoplock.se/dept/--Makulatur--sulfitpapper_77613/SWE/SEK

Sulphite paper
White, bleached, paper used for same purposes as waste and silk paper.
Available in 230 m rolls with 57 cm width with a price of 288 SEK/roll (= 2,20 SEK/m^2).
http://www.packoplock.se/dept/--Makulatur--sulfitpapper_77613/SWE/SEK

iv. Pads:

Corrugated paper pads ("welldynor")
Strong "blocks" of corrugated paper that are used as shims, structural support, filling and protection for corners of products being packaged.
Available two sizes;
package of 20 units of 10x10x116 cm pieces costs 684 SEK (= 34,2 SEK/piece) and
package of 180 units of 10x1,5x75 cm pieces costs 690 SEK (= 3,83 SEK/piece).
http://www.packoplock.se/dept/--Welldynor_51244/SWE/SEK

Nomapack "U-profiles"
Profiles made out of LDPE used to protect corners and edges.
Available in sizes ranging from:
thickness of 7 mm and a gap of 15 mm with a price of 3052 SEK for a package of 560 pieces (= 5,45 SEK/piece) to
thickness of 12 mm and a gap of 45 mm with a price of 1890 SEK for a package of 180 pieces (= 10,5 SEK/piece).
http://www.packoplock.se/dept/--Nomapack-kantskydd_91166/SWE/SEK

Nomapack "L-profiles"
Profiles made out of LDPE used to protect corners and edges.
Available with either:
thickness of 6 mm and width of 50 mm with a price of 3216 SEK for a package of 480 pieces (= 6,7 SEK/piece) or
thickness of 10 mm and width of 75 mm with a price of 4190 SEK for a package of 210 pieces (= 19,95 SEK/piece).
http://www.packoplock.se/dept/--Nomapack-kantskydd_91166/SWE/SEK

EPS corner protection
Pieces of molded expanded polystyrene that fits corners of various products.
Available in sizes ranging from
77x50x20 mm in packages of 3000 pieces with a price of 3685 SEK (1,22 SEK/piece) to
87x60x10 mm in packages of 5000 pieces with a price of 3670 SEK (= 0,7PS3 SEK/piece).
http://www.packoplock.se/dept/--Kant---hornskydd-i-EPS_74747/SWE/SEK

EPS L-profiles
Profiles of molded expanded polystyrene that fits edges of various products.
Available in sizes ranging from
55x10x1000 mm in packages of 1000 pieces with a price of 3600 (=3,6 SEK/piece) to
90x30x1000 mm in packages of 270 pieces with a price of 3820 SEK (= 14,15 SEK/piece).
http://www.packoplock.se/dept/--Kant---hornskydd-i-EPS_74747/SWE/SEK

APPENDIX IV - PRODUCT INFORMATION AND TECHNICAL SOLUTIONS FOR COOLING BAGS

Picnic bags <200 kr	Price [SEK]	Volume [liters]	Retailer
Clas Ohlson 34-9873-4	49	6	Clas Ohlson
Igloo Small Square	149	9*	jakto.se
Igloo Duffel Small	199	7*	jakto.se
Igloo Cooler Tote	189	9	jakto.se
Kayoba 18 l	129	18	Jula
Kayoba 22 l	89	22	Jula
Jula 958030	19	6	Jula
Jysk 4700200	99	20	Jysk
Jysk 4710900	30	4	Jysk
Sagaform Kylväska 5016077	45	5,8*	Shopping4net.se
Sagaform Paradise Kylväska	139	12	Shopping4net.se
Queen Anne Kylväska 22 l	119	22	texstyle.se
Queen Anne Kylbag 15 l	119	15	texstyle.se
IKEA Solur 702.379.33	99	18*	IKEA
Sagaform Hopfällbar kylväska	179	17*	designonline.se
Average price (SEK):	**110**		

Picnic bags >200 kr	Price [SEK]	Volume [liters]	Retailer
Igloo Anchors Away Sail Tote	299	8	benns.se
Menu Cool Bag	599	4,8*	frapp.se
Outwell Chill-bin M	280	15	getcamping.se
Igloo Realtree 18can Gripper	579	15*	jakto.se
Queen Anne Multi	219	12	texstyle.se
Average price (SEK):	**395**		

*the volume is an estimation based on outside dimensions

Picnic baskets	Price [SEK]	Volume [liters]	Retailer
Biltema 47154	149	35*	Biltema
Clas Ohlson 34-9872-2	149	26	Clas Ohlson
Clas Ohlson 34-9600-1	99	26	Clas Ohlson
Sagaform Blue Oasis Kylkorg	199	25	designonline.se
Jula 958036	149	30	Jula
Jysk 4700500	99	20	Jysk
Queen Anna Carry	179	30	texstyle.se
Average price (SEK):	**146**		

Backpacks	Price [SEK]	Volume [liters]	Retailer
Sagaform Paradise Kylryggsäck	179	15*	frapp.se
Huddig Kylväska Skagen	190	18*	huddig.se
Didgeridoonas The Autralian Walkabout Cooler Bag	780	13	12oz.se
Average price (SEK):	**383**		

For beverage	Price [SEK]	Volume [liters]	Retailer
Benns 490541	149	3	benns.se
Clas Ohlson 34-8898	129	3	Clas Ohlson
Sagaform Blue Oasis Multi Kylväska	99	7	designonline.se
Menu Baggy Winecoat	499	3	designonline.se
Didgeridoonas 6 Pack Cooler Bag	560	11*	12oz.se
Didgeridoonas The Australian Tucker Bag	580	14	12oz.se
Didgeridoonas The Australian Hiker's Water Holder-Large	340	1,2	12oz.se
Didgeridoonas The Wolly Wine Cooler	350	2*	12oz.se
IKEA Solur 902.379.32	99	19*	IKEA
Average price (SEK):	**312**		

Children's cooling bags	Price [SEK]	Volume [liters]	Retailer
Biltema 47153	75	9	Biltema
Average price in SEK:	**75**		

Average price in total for all categories (SEK):	217

*the volume is an estimation based on outside dimensions

APPENDIX V - PRODUCT INFORMATION AND TECHNICAL SOLUTIONS FOR PLAYING MODULES

Large sets of modules ≥ 10 pieces	Price [SEK]	Nr of pieces	Retailer
Leika 3165100 - Bobles förskoleset	18455	17	leika.se
Leika 31364000 - Multicircles large 1	41135	11	leika.se
Leika 780240 - Modulset c eko bomull	5334	10	leika.se
Leika 780250 - Modulset e kvadrat	6099	11	leika.se
Leika 780260 - Modulset f eko bomull	9027	12	leika.se
Leika 784008 - Modulset a kvadrat	6099	10	leika.se
Leika 785000 - Byggmodulset 10 kvadrat	3330	10	leika.se
Leika 785001 - Modulset j techmadin 10 st	14763	18	leika.se
Leika 785002 - Modulset g 18 st techmadin	11071	18	leika.se
Leika 785200 - Byggmodulset 20 kvadrat	5532	20	leika.se
Leika 785400 - Motorikmodulset g kvadrat	11071	16	leika.se
Leika 1325000 - Wesco gigant set 19 moduler	31182	19	leika.se
Leika 77052 - Småbarnsmodul stort set	11071	12	leika.se
Leika 1324951 - Småbarnsmodul bro	11994	13	leika.se
Leika 1324954 - Småbarnsmodul gigant	16610	19	leika.se
Lekolär 35611 - Byggsats Konfekt	4610	10	lekolar.se
Lekolär 35683 - Byggsats 14	5100	14	lekolar.se
Lekolär 35502 - Byggsats Lekis Multi-Soft	4845	10	lekolar.se
Lekolär 35684 - Byggsats 20	7117	20	lekolar.se
Lekolär 35578 - Byggsats Portal	4580	14	lekolar.se
Lekolär 35689 - Byggsats rektangel 10 delar	2750	10	lekolar.se
Lekolär 36500 - Byggsats 14 Pastell	6850	14	lekolar.se
Lekolär 36501 - Byggsats 20 Pastell	7950	20	lekolar.se
Lekolär 36502 - Byggsats Portal Pastell	5650	14	lekolar.se
Lekolär 36503 - Byggsats Rektangel 10 delar Pastell	3950	10	lekolar.se
Lekolär 35524 - Active Playstation	8585	19	lekolar.se
Average price/set in SEK:	**10183**		
Average nr of pieces/set:	**14**		
Average price/piece in SEK	**722**		

Small sets of blocks < 10 pieces

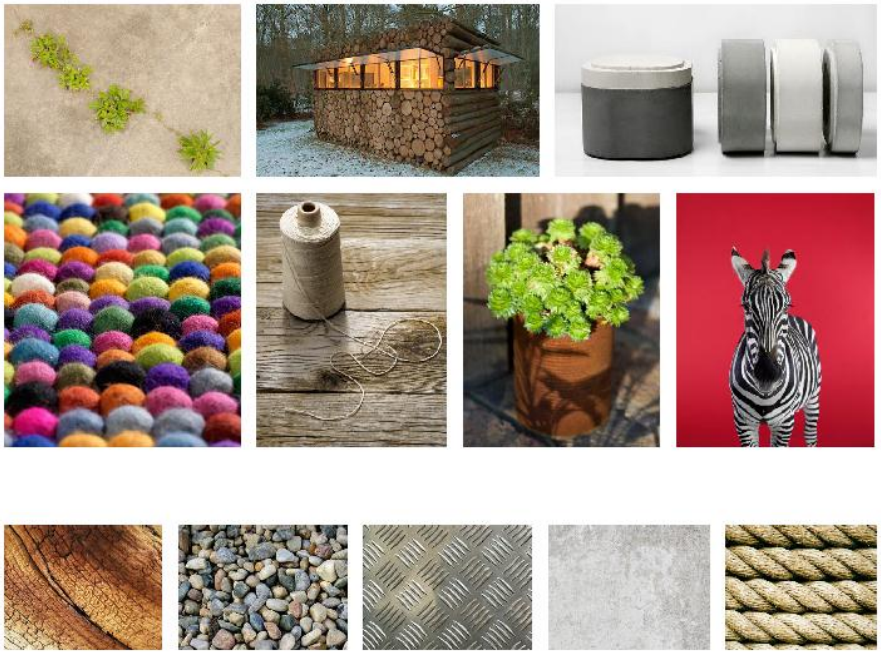
Leika 3165000 - Bobles dagisset	9224	9	leika.se
Leika 31361000 - Multicircles medium 1	18849	6	leika.se
Leika 31362000 - Multicircles medium 2	16620	5	leika.se
Leika 784005 - Modulset b eko bomull	5136	8	leika.se
Leika 784015 - Modulset d kvadrat	5334	9	leika.se
Leika 77053 - Modulset 1 - 4 modulet	5532	4	leika.se
Leika 72077 - Modulset 2 - 5 moduler	8473	5	leika.se
Leika 1320143 - Småbarnsmodul trin	7378	6	leika.se
Leika 1320288 - Modulset ring - 4 moduler	9027	4	leika.se
Leika 1320300 - Pyramidset - 4 moduler	7378	4	leika.se
Leika 1320301 - Set med 3 ingångar - 7 moduler	11071	7	leika.se
Leika 1324948 - Småbarndmodul sving	5532	6	leika.se
Leika 1324949 - Småbarnsmodul litet galleri	7022	5	leika.se
Leika 73076 - Modulset 10 - 4 moduler	7378	4	leika.se
Tress 945956 - Skumhus Multi	8990	-	tress.se
Lekolär 35087 - Motorikset F	5050	6	lekolar.se
Lekolär 35084 - Motorikset C	4055	3	lekolar.se
Lekolär 35083 - Motorikset A	3835	4	lekolar.se
Lekolär 35085 - Motorikset D	4080	3	lekolar.se
Lekolär 35537 - Valv & halvcirkel	1755	2	lekolar.se
Lekolär 35478 - Vågen Lekbana komplett set	10795	6	lekolar.se
Average price/set in SEK:	**7739**		
Average nr of pieces/set:	**5**		
Average price/piece in SEK	**1504**		

Animals & other shapes

Leika 1324732 - Skumdjurset 4 st	6455	4	leika.se
Timehome 10-4521402 - Anka	399	1	timehome.se
Timehome 10-4521400 - Delfin	399	1	timehome.se
Timehome 10-4521401 - Groda	399	1	timehome.se
Timehome 10-4521152R - Rocket Bean Rosa	299	1	timehome.se
Lekolär 35538 - Bananen	1805	1	lekolar.se
Lekolär 35474 - Buclo stor grön	1705	1	lekolar.se
Average price/piece in SEK:	**946**		

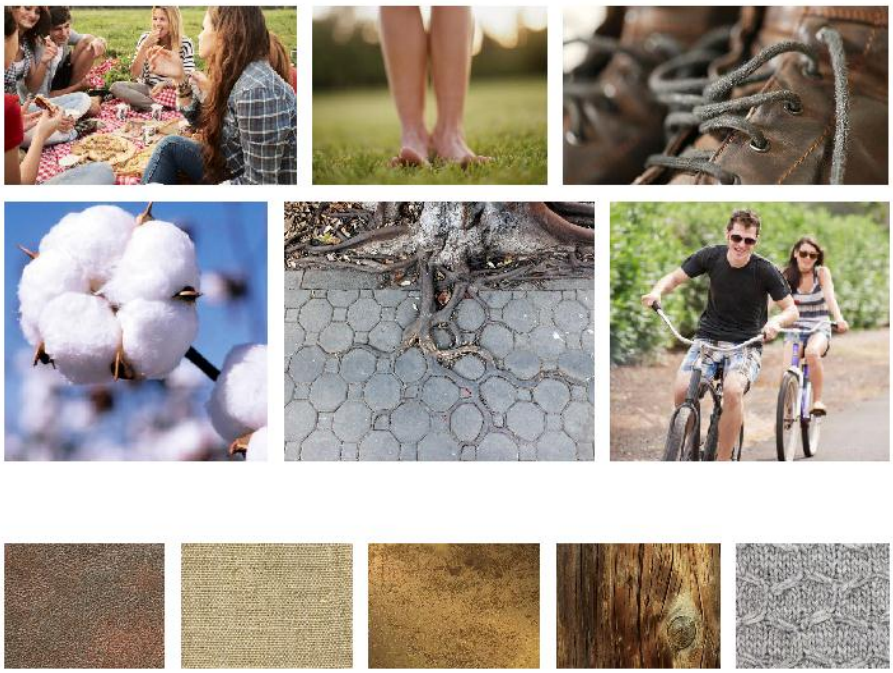
APPENDIX VI – IMAGEBOARDS

Imageboard for lamp



Keywords: Unique, modern, natural

Imageboard for cooling bags



Keywords: Modern, natural/organic, durable, urban

APPENDIX VII – MORPHOLOGICAL MATRIX FOR SCREEN-WALLS

FUNCTION	**SUB-SOLUTIONS**		
Design of PUR panel	Sheet	Folded sheet	
Base	Single base	Multiple base	Shared multiple base
Mobility	With wheels	Without wheels	
Interface panel-base	Pipes/profiles	Bracket	

APPENDIX VIII – PUGH MATRICES FOR SCREEN-WALLS

Pugh 1: Screen-walls **Criteria**	**Referece** Combinable base	Angled base	Flexible walls
Manufacturability	0	1	0
Safety	0	0	0
Maintenance	0	-1	0
Durability	0	0	-1
Aesthetics	0	-1	1
Cost	0	1	0
Market potential/business opportunity	0	-1	0
Portability and assembly (user)	0	1	1
Stability	0	0	-1
Weight	0	0	1
Customizability	0	-1	1
Total:	**0**	**-1**	**2**
Ranking:	**2**	**3**	**1**

Pugh 2: Screen-walls **Criteria**	**Referece** Flexible walls	Angled plate	Combinable base
Manufacturability	0	1	0
Safety	0	0	0
Maintenance	0	-1	0
Durability	0	1	1
Aesthetics	0	-1	-1
Cost	0	1	0
Market potential/business opportunity	0	-1	0
Portability and assembly (user)	0	1	-1
Stability	0	0	1
Weight	0	-1	-1
Customizability	0	-1	-1
Total:	**0**	**-1**	**-2**
Ranking:	**1**	**2**	**3**

Pugh 3: Screen-walls **Criteria**	**Referece** Angled base	Flexible walls	Combinable base
Manufacturability	0	-1	-1
Safety	0	0	0
Maintenance	0	1	1
Durability	0	-1	0
Aesthetics	0	1	1
Cost	0	-1	-1
Market potential/business opportunity	0	1	1
Portability and assembly (user)	0	-1	-1
Stability	0	0	0
Weight	0	1	0
Customizability	0	1	1
Total:	**0**	**1**	**1**
Ranking:	**2**	**1**	**1**

APPENDIX IX – PUGH MATRICES FOR PLAYING MODULES

Pugh 1: Playing modules	**Referece**		
Criteria	Puzzle	Bricks & sticks	Forest
Manufacturability	0	-1	0
Safety	0	0	0
Durability	0	-1	0
Aesthetics	0	-1	0
Cleaning and maintenance	0	-1	0
Cost	0	0	0
Market potential/business opportunity	0	0	0
Mental activity	0	0	0
Space efficiency	0	0	-1
Fun and playful	0	0	1
Versatility	0	0	0
Total:	**0**	**-4**	**0**
Ranking:	**1**	**2**	**1**

Pugh 2: Playing modules	**Referece**		
Criteria	Forest	Bricks & sticks	Puzzle
Manufacturability	0	-1	0
Safety	0	0	0
Durability	0	-1	0
Aesthetics	0	-1	0
Cleaning and maintenance	0	-1	0
Cost	0	0	0
Market potential/business opportunity	0	0	0
Mental activity	0	0	0
Space efficiency	0	1	1
Fun and playful	0	-1	-1
Versatility	0	0	0
Total:	**0**	**-4**	**0**
Ranking:	**1**	**2**	**1**