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RESOURCE EFFICIENT PERSONAL COOLING TO A LOW COST

- product development project based on a ethnographic study in Indonesia

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Cover photo:

Final concept - a customisable personal cooling product. See chapter 12 for further information.





PREFACE

This project has been conducted as a master thesis project at Industrial Design Engineering at Chalmers by one student, hereafter referred to as the researcher. It was a project supported by SIDA's Minor Field Study scholarship for field studies in developing countries.

My greatest thanks to all people, organisations and companies that have supported the project on the way, especially to my Indonesian guides and the university of Surabaya for your great hospitality.

ELIN KRISTELL





ABSTRACT

Temptech is a phase change material, coated in aluminium, that absorbs heat and therefore provides a pleasant cooling at temperatures above its own transition temperature at 28°C. The Temptech element becomes 'recharged' when placed in temperatures below 24°C.

Indonesia today is a country with relatively good economic growth and a growing middle class. This leads to an increased use of electricity, of which artificial cooling accounts for a great part. The use of energy adds a large cost on the national budget in Indonesia and another cost on the environment. Cooling is needed, and a sort that is more resource efficient and has less environmental impact, such as Temptech, could be a benefit to Indonesia and its inhabitants.

The first phase of the project was a pre-study to understand the need for cooling, both from the human body's and the Indonesian market's perspective. A gap in the market, for lightweight, affordable and portable personal cooling products was found, not only in Indonesia but also worldwide.

In the second phase, an eight week long ethnographic field study was accomplished. Insights about heat related behaviours and experiences, as well as a deeper knowledge about physical environments in Indonesia, were collected, structured and analysed.

The third phase, product development of a cooling product, took part at Chalmers, Gothenburg. The final proposed concept is designed as a simple cooling section, which can be combined to a belt by two or more sections, containing two Temptech elements each. The belt can be adapted to the user's needs and various hot usage situations, by adapting the lengths and placement of the belt. It can be worn, for example around the waist or arm, or placed on surfaces to sit or lie on, such as a car seat or office chair.

The developed cooling product is resource efficient, affordable and can be used for a long time by many different people. It provides a great opportunity to introduce a natural cooling technology on the Indonesian market. Not only to meet the need of people but also the environment.

Keywords:

cooling belt, cooling seat, personal cooling, phase change material, resource efficiency, product development for developing countries, sustainable product development, minor field study, Indonesia.

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INTRODUCTION



1. BACKGROUND

Already well known is that heat can affect people negatively. To be able to perform at a high level, the human body must be kept within its thermal comfort zone. This is not always possible and results in hampering of both the people and their performance.

When thinking of a pleasant and comfortable temperature in a tropical environment, the technology that comes to one's mind is often air-conditioning. But what if there are other alternative cooling technologies? Alternatives that can be used whenever or wherever one wants to and needs to, such as in an outdoor activity or where electricity is scarce?

The answer is yes, and one such technology is Temptech, a phase change material from TST Sweden. Temptech has no requirement for electricity, which makes it useful in a wide range of products, from stabilization of body temperature to office cooling. Temptech has already shown its advantages as a personal cooling product, in a cooling vest for workers in extreme heat.

Temptech is available on the market but not yet recognised for its usefulness in all parts of the world. It has great potential to provide developing and emerging countries with sustainable cooling products, due to its free recharging, long lifetime and low environmental impact.

1.1. QUESTION FORMULATION

Two parts are combined in the question formulation; the potential of Temptech element as personal cooling in non-extreme situations and the special need and requirements on a cooling product to be used in Indonesia or similar environments. The main question has been:

- How should a personal cooling product be designed to be affordable and suitable for users suffering in hot environments and at the same time maximise the cooling given from the Temptech elements?

1.2. AIMS

- Get a deep understanding for the need of cooling products in Indonesia
- Design a personal cooling product adapted for the Indonesian market, desirable in a variety of situations and by various users

1.3. OBJECTIVES

- Find potential users for a cooling products in Indonesia
- Identify the need and requirements on personal cooling in Indonesia
- Understand the benefits and possibilities of Temptech cooling in non-extreme heat situations
- Propose a cooling product, based on the findings from the study, that is suitable for the Indonesian market and the identified potential users

1.4. DELIMITATIONS

This product development project had its starting point in the Temptech thermal element and on the Indonesian market. Indonesia is a country with an emerging economy hungering for new and useful products, especially products which fulfill the need for personal cooling.

Main limitations were:

- The project is founded by Minor Field Study (SIDA), which means that one specific country, Indonesia, and its inhabitants are of main focus for all parts of the project.
- The study will take part in Indonesia, which will largely influence the product development and emphasize the needs found in this specific country. Therefore, usefulness of the product in other countries and in other situations cannot be guaranteed.
- A product for personal cooling will be developed, due to a request from TST Sweden.
- Temptech element with a transition temperature of 28°C will be used.
- Temptech element with the same size as in other personal cooling products, for example the Cooling Vest. This is due to the fact that this size of the element has been well sized and reduces cost.
- This project investigates non-extreme situations in naturally hot environment.

2. TST SWEDEN AB

As a reaction to clumsy and out-dated protective wears, seen in industries in the late 80's, Jörgen Liljeroth founded TST Sweden (Figure 1) in 1990, as an attempt to modernise and improve this technical clothing. The first products were protective clothing against extreme heat.

Twenty years later TST Sweden has developed some of the most advanced protective products available on the worldwide market. Based on the users need and wellbeing, TST Sweden is constantly pushing the

technical development ahead. The company strive not only to sell technically advanced protection but also consider comfort to be a key factor in the product development.

TST Sweden produces protective clothing for a wide field of extreme situations, from water jetting and chemicals to cooling. Waterjet protection is the main area, while this project is in the field of cooling. (TST Sweden)



Figure 1: TST Sweden Logo (TST Sweden)

2.1. TEMPTECH ELEMENT

Temptech is a phase change material with sodium sulphate (salt) as its main functioning ingredient, apart from water. It is a latent heat storage material that is non-toxic and non-flammable. Technological information about Temptech with transition temperature at 28°C is shortly presented in Table 1.

As other phase change material, Temptech absorbs and releases heat when it changes phase, e.g. from solid to liquid and reverse. This means Temptech has two types of thermal effects, a cooling effect when it melts and a heating effect when it solidifies.

Temptech element (Figure 2) has a capacity to cool for up to 4 hours at 45°C (TST Sweden 2012) and the time it lasts depends on, for example, the body temperature, the level of physical activity and the design of the garment (Gao et al 2011). The function of a phase change material is dependent on the temperature gradient, the amount of phase change material and its conductivity (Table 2) (Climator 2012).

The transition temperature depends on what additives the Temptech element contains. Phase change

temperature of 24°C, 28°C and 32°C have previously been used in body cooling products where the most widely used transition temperature is 28°C. A lower transition temperature will cool faster and more intensive, which also means that it will cool for a shorter period of time.

When a Temptech element is exposed to a surrounding temperature above its transition temperature, for example, placed in contact with the skin, it begins to absorb heat and change phase. As long as the phase change is processing the Temptech element will provide a comfortable and soothing cooling effect. An element that has become completely melted, has no longer any heat absorbing capacity and needs to be recharged.

The elements become recharged in temperatures 2-4°C below its transition temperature and the colder it is placed, the quicker it is charged. Heat absorption and charging can be repeated over and over again. This makes the Temptech element resource efficient and opens the product usage to where the supply of electricity is scarce. (TST Sweden 2012)

Table 1: Temptech - product information

PHASE CHANGE TEMPERATURES	28°C
SIZE	7*12.5 centimetres
WEIGHT	70 grams
LATENT HEAT	126 Joule / gram
SPECIFIC GRAVITY	1.42 kilogram / litre
THERMAL CONDUCTIVITY	0.5–0.7 watt / meter / °C

“Test of the Temptech technology has proven that it is effective in helping combat the rise in a person’s body surface temperature and reduce heat stress when in hot environments.”

(TST Sweden 2012)

(TST Sweden 2012)

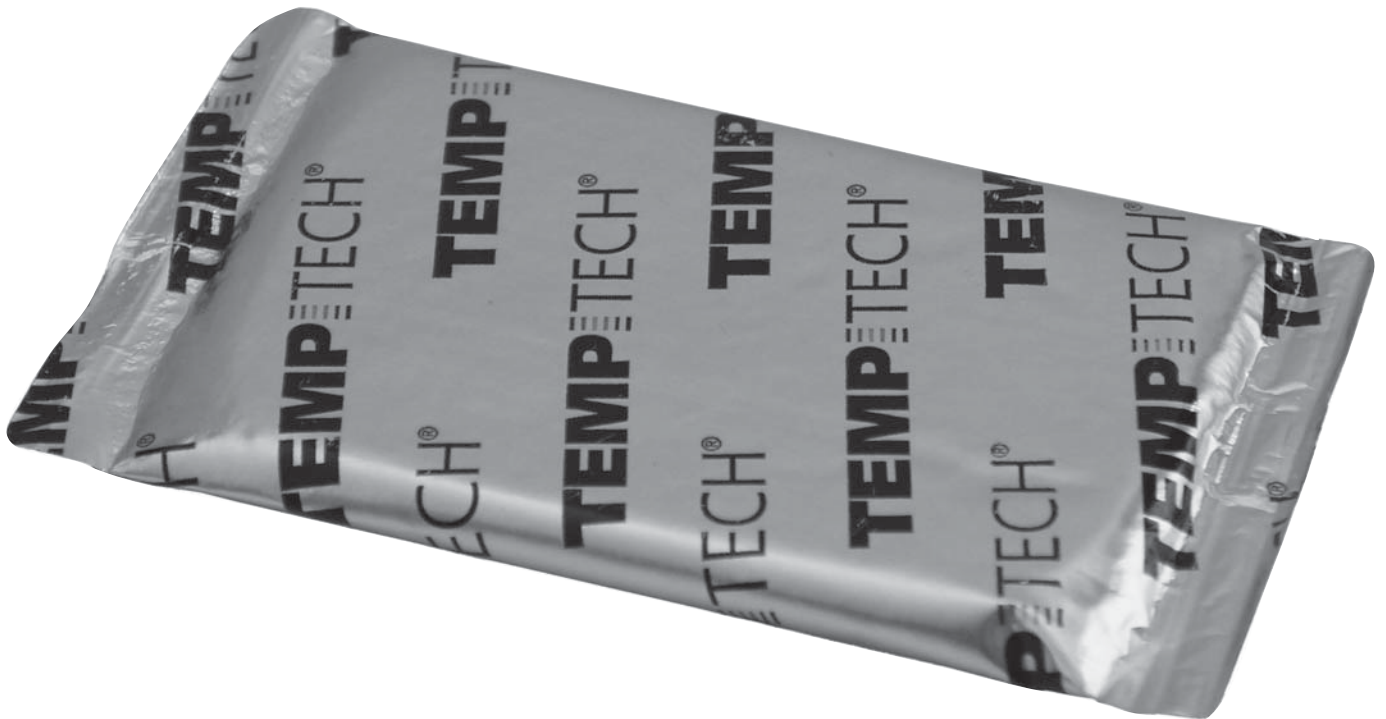


Figure 2: Temptech element (TST Sweden 2012)

Table 2: The function of phase change material depends on:

TEMPERATURE GRADIENT	The difference between the Temptech element's transition temperature and the surrounding temperature - the bigger this difference is the faster the phase change will occur
AMOUNT OF PHASE CHANGE MATERIAL	More phase change material equals more storage capacity and will take longer to charge and discharge
CONDUCTIVITY	The faster the energy transfers from the surrounding phase change material, the faster the phase change material will occur

(TST Sweden 2012)

2.1.1. COOLING VEST

An example of a personal cooling product from TST Sweden is the Cooling Vest (Figure 4). This product was initially developed in cooperation with the Swedish Rescue Service to reduce the heat load on firefighters. The vest is available in some different variants for diverse, extreme situations, but is used by an even broader group of users; from firefighters to musical artists and racecar drivers to those who are suffering from illnesses negatively affected by the heat. (TST Sweden)

The Cooling Vest is made of polyester and has inside pockets for cooling elements to be put in. One Cooling Vest uses 16 to 22 Temptech elements, depending on model, and weights around two kilograms.

The latent heat, the heat absorption capacity, in one cooling vest with 21 Temptech elements is 277 kilojoule (Gao et al 2011). In a study where this cooling vest was worn in 55°C while the user had to perform physical activity for about one hour, Gao et al. (2011)

calculates the heat absorption capacity relative the metabolic heat production (250 Watt / meter²) to be approximately 20 percent of the total body heat, assuming the element does not absorb heat from the surroundings and becomes completely melted.

Other findings from the same study were that the Cooling Vest lowered the torso skin temperature by 2.5-4°C, lowered the whole body skin temperature by about 1°C, decreased increase of body temperature and decreased the sweat production, relative to them not wearing a cooling vest. (Gao et al 2011)

The cooling vest's marketing material illustrates the differences between wearing a vest and not, while performing different activities in a hot environment (55°C). This result is reproduced in Figure 3, where the extra minutes within the comfort zone, given a person with a cooling vest, is the gap between the red and green line at the height where both the curves are crossing the comfort temperature line.

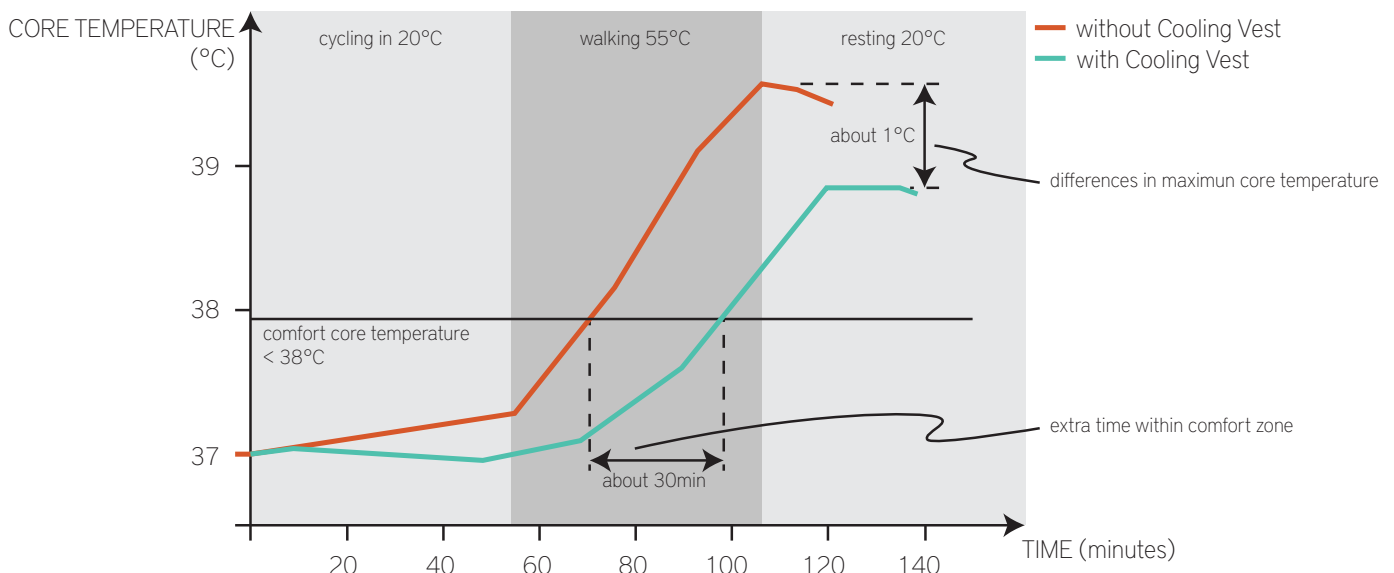


Figure 3: Graph that shows the differences in core temperature and time, between them wearing a cooling vest and them not wearing a cooling vest (TST Sweden 2012)



Figure 4: Cooling vest from TST Sweden (TST Sweden 2012)



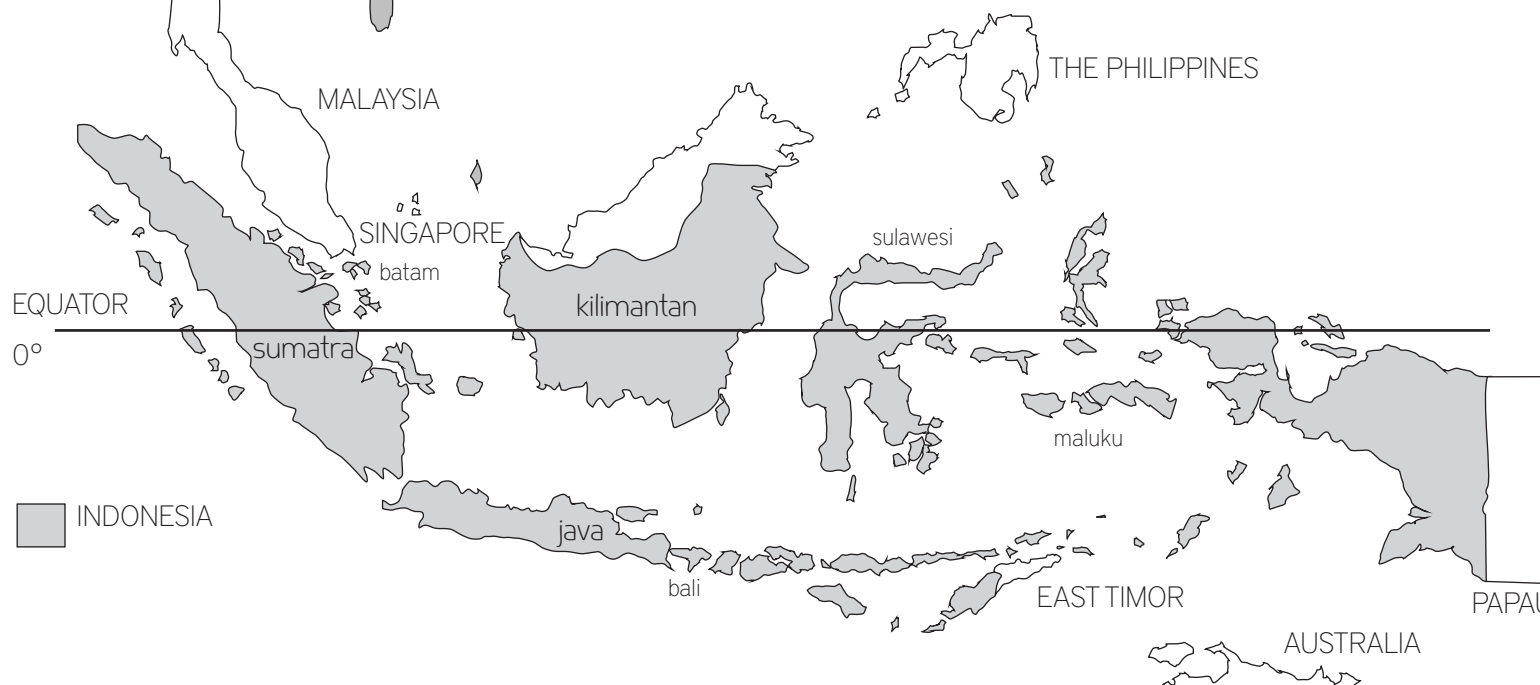


Figure 5: Map of Indonesia

3. INDONESIA

3.1. COUNTRY INFORMATION

With its 240 million inhabitants, The Republic of Indonesia is the world's fourth most populous country. Indonesia comprises of more than 18 000 islands (Figure 5), 400 ethnic groups and 400 diverse languages. A wealth of cultures and religions, such as modern cities, forager societies in Guinea Papua and orthodox Muslim in Ache, are included in the Indonesian society.

The constitution, firstly written in 1945 but changed after that, contains the official philosophical foundation of the Indonesian state that comprises five principles for the country; belief in God, humanity, national unity, democracy and social justice. The constitution states that all Indonesians must believe in a God. Religious freedom is guaranteed for Hindus, Buddhists, Muslims, Catholics, Protestants and Confucians and nearly 90 percent of the inhabitants profess to Islam. This makes Indonesia the world's most populous Muslim country.

The national language, Indonesian, is young but has opened up for better understanding between different parts of the country. The Indonesian motto says "Bhinneka Tunggal Ika", unity in diversity.

Political instability and regional separatism combined with natural disaster have hindered the country's development. The standard of living and health in general has improved significantly since the 1960's and the life expectancy has increased by more than 20 years at the same period of time. Healthcare has been improved by new health centres and vaccination pro-

grams. Also the quality of water has been improved. But the high maternal and infant mortality is still a main problem and so is malnutrition in children. (Utrikespolitiska Institutet 2012)

3.1.1. ECONOMY

Indonesia fared the 2008 global financial crisis better than their export-dependent neighbouring countries and has become one of Asia's strongest economies in 2011. This was due to domestic private consumption - 60percent of the economy - but also thanks to export and foreign investments.

In 2005 Indonesia regained its status as a middle-income country that was lost in the economic crisis of Asia in 1997. A crisis that made the poor part of the population increase from one tenth in 1996 to one third in 1999, and this is where it has remained until today. Half of the Indonesian population survive on less than two American dollars a day. (Utrikespolitiska Institutet 2012)

3.1.2. CLIMATE

Indonesia has a tropical climate with high humidity. The main day temperature is 27-28°C, colder in mountainous areas and warmer in the city areas. Roughly, Indonesia has two seasons; the warm and wet in December to March and the warm and dry in June to September. (Utrikespolitiska Institutet 2012)

3.2. EMERGING MARKETS

Emerging markets - approximately the 80 percent of the global population that represent about 20 percent of the worlds economies – is a term invented in the early 1980's by Antoine Van Agtmael. Countries are considered emerging because of their developments, for example economic, and reform programs. The term is loosely defined and so are the countries included, from China to Tunisia. Indonesia is today almost always included in this category of country. (Heakal 2009)

3.1.3. ELECTRICITY

Energy requirements in Indonesia is increasing significantly every year and the rise is expected to be even higher in a few years. In Indonesia this will be a burden to the state budget as the selling price is lower than the production cost, and only covers 66 percent (Jakarta Post 2012). More than 80 percent of the electricity consumers in Indonesia belong to a group that use very little electricity and have the lowest prise to pay, but cannot afford to pay any increased prise due to very low income. (Jakarta updates 2010)

Renewable energy sources only contribute to less than five percent of Indonesia's total energy use, which means more than 95 percent is fossil feul. A vision from the Energy and Mineral Resources Ministry, Vision 2025, expect the use of renewable energy to reach 25 percent by 2025. (Faizal 2012)

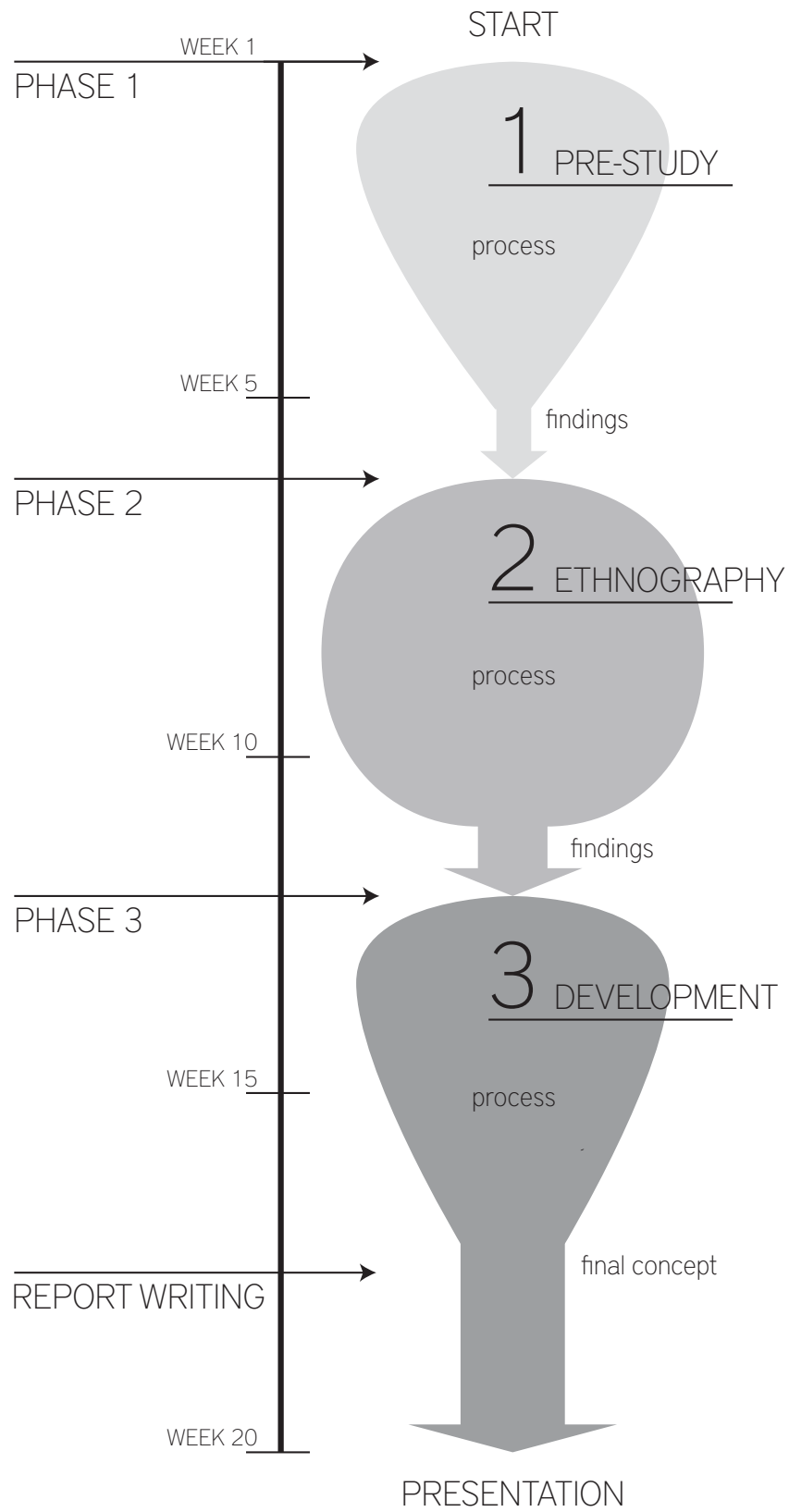
To meet the increase of energy and the vision of renewable sources, energy has to be efficient and smartly consumed and sustainable solutions promoted (Jakarta updates 2010), which also means that the consumer behaviour has to change (Faizal 2012).

Examples of energy used by electrical equipment and the cost of use in Indonesia are presented in Table 3.

Table 3: Examples electrical equipment's energy use (Rp = Rupiah and SEK = Swedish krona)

60 WATT LIGHT BULB (6 HOURS / DAY = 130 KILOWATT-HOURS / YEAR)	95 000 Rp	80 SEK
FLOOR FAN OR BOX FAN (6 HOURS / DAY = 223 KILOWATT-HOURS / YEAR)	160 000 Rp	130 SEK
SMALL REFRIGERATOR (24 HOURS / DAY = 636 KILOWATT-HOURS / YEAR)	465 000 Rp	390 SEK
MEDIUM WINDOW UNIT AIR-CONDITION (2000 KILOWATT-HOURS / YEAR)	1 460 000 Rp	1200 SEK





4. PROJECT PROCESS

The project process has been divided into three main phases; pre-study, ethnography and development as seen in Figure 6. The pre-study was further divided into literature study, market research and user definition. The ethnography involved an 8 weeks field study in Indonesia and the development contained the ideation and product development, as well as the presentation of one final proposed concept of a cooling product adapted for the potential Indonesian users and the Indonesian market.

Figure 6: Project process





METHODS

5. DESCRIPTION OF METHODS

5.1. PHASE 1 : PRE-STUDY

5.1.1. LITERATURE REVIEW

Literature review is used to summarise, structure and understand previous research and information, which can be found in books, scientific articles and other publications.

5.1.2. SECONDARY SOURCE REVIEW

Secondary sources, such as blogs, photographs and forums are other sources of useful information, but not always published by reliable and trusted agencies. Secondary source publications allow people to talk openly and directly from the heart, for example because they are not censured or have to be based on research. These can provide the study with background data, sometimes not considered as suitable or correct as, for example, a research report or government publication. This widens the background study and supplies it with new and interesting approaches to the studied topic.

5.1.3. COMPETING PRODUCTS

To be able to find market gaps and new approaches it is valuable to know and analyse possible competitors. Competing products is a method to help the project to find products that meets the same need as the one to be developed that is already on, or on the way to, the market. Competing products are often found on Internet, for example in forum and web shops. (Visocky 2006)

5.1.4. MOOD BOARD

A mood board is a tool to communicate and visualise, internally or externally, facts, feelings or expressions as a collage of mostly images. It contains samples of images and objects that summarise and express important information found in the study. This tool is used in all phases of the project.

5.2. PHASE 2 : ETHNOGRAPHY

5.2.1. ETHNOGRAPHIC RESEARCH

Ethnographic research is a strategy originally created by anthropologists, but beneficially used in design projects too. It helps to obtain information about cultures and people from the users own perspective. It is a qualitative research method focusing on providing deep understanding of the link between human behaviour and culture. Techniques used in the data collection are observations, interviews and photo ethnography as seen in Figure 7.

The study starts with finding and choosing participants, based on suitable characteristics such as geographic location, interests, ages or other. Background

information about the chosen community is collected, for example by literature research, to identify questions to be examined. Thereafter interviews, observations and additional tools are used in a field study, where the participants own values are searched for. Recordings, field notes and photographs will confirm the result distilled in the study.

Because the ethnographic study involves study and interaction with human beings, the researcher must take ethical into consideration; participants must agree to be part of the study. (Visocky 2006)

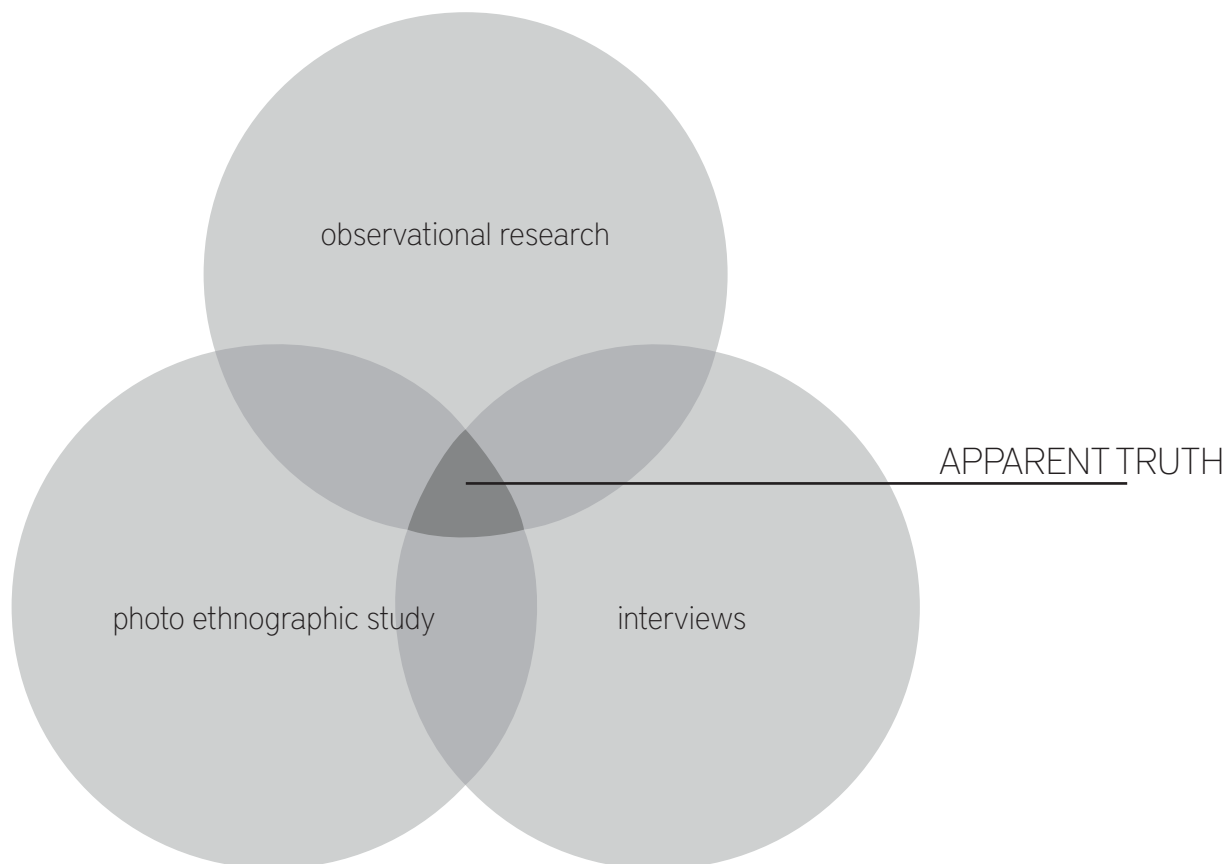


Figure 7: Ethnographers use a combination of techniques in their research (Visocky 2006)

5.2.2. USER GROUP

By defining a user group, a group of potential users with carefully selected characteristics, it is possible to find and talk to the right people, the people that have insight and knowledge about the area of interest for the project. By knowing whom the users are it is possible to investigate their experiences, advantages and shortcomings of existing products similar to the one being developed. User groups make it possible to find needs and interests, specific and common, to base the product development on.

A user group can be categorised in several ways, depending on the aim of the project. Various factors or main characteristics, for example demographic, geographic, lifestyle and benefits of the product, can be chosen. Most important is that the group is defined in a way that is useful for the study and makes the requested information accessible for the development team.

5.2.2.1. Context

Awareness of the context in which a product will be used is very important and helps the development process.

The physical context is the location and physical environment, not only as in borders and structures but also the understanding of the place and the individuals. Distinguishing different environments result in different human reactions. Humans are, for example, affected by the ambient environmental conditions such as temperature and humidity, the ergonomics such as furniture design and light environment, the architecture such as building material and design.

To fully understand people, knowledge of the social context is very important. Social context is the culture in which an individual was educated and / or lives in and the people and traditions from which a person gets influenced. Everything from our social past, from the nation in which we live to the books we have read, influences how we interpret the world. A social context builds the framework for what is defined as important questions and issues to every individual, but is also a shared understanding of what 'works' in a specific situation.

5.2.3. OBSERVATION

Observation is a method to collect data about users and usage situations, with as little impact on the real situation as possible. Observations make it possible to collect data that is not told, for example, because the respondents think it is too banal or they are not aware of the action.

The researcher can deepen the understanding of the user and user situation even more by experiencing the situation and context of the study in a way similar to how the users do, as a participant observer. In this case, the observation is undertaken over an extended period of time, which means that more detailed and accurate information can be collected.

5.2.4. INTERVIEW

Interviews are often the main method of data collection and can be varied and adapted to the situation depending on what data the project requests. It is a method to collect subjective thoughts, opinions and attitudes, expressed by the users themselves while talking about topics chosen by the researcher. (Bohgard 2009)

A focus group is an interview situation where a group of people is asked to participate and talk about a pre-determined topic. Objects and images are sometimes used as triggers for discussion. (Bohgard 2009)

Open session is an informal and unstructured data collection method, similar to the focus group. It involves discussions and creative activities, based partly on prepared topics and partly of what the group comes up with. This is a method that opens up minds, both the participants' and the researcher's.

5.2.5. PHOTO ETHNOGRAPHY

In photo ethnography the participants are asked to record their daily activities with a camera or video camera. The researcher will broaden the understanding of the participants and their context by analysing the images or movies captured. (Visocky 2006)

5.2.6. KEY INFORMANTS

A key informant is a person chosen to be an expert source of information because of personal skills or position within a society that will provide the project with a deeper insight to the context of study. Advantageous for this method is that a large amount of quality data can be collected in a relatively short period of time. A weakness of the method is that one or a few persons may not represent the majority view of a whole user group. (Bernhard 2002)

5.2.7. ASSESSMENT WORKSHEET

Image and illustrations are used to reach a wider group of users, for example, those who cannot easily express themselves in words. It is also a useful tool when language is an obstacle to overcome.

An illustrated and almost wordless assessment worksheet was in this project used as a data collection method to make the participants and researcher meet on a common starting point and understanding of each other.

5.2.8. KJ-ANALYSIS

KJ-analysis is a tool to organise data into groups based on different relationships and characteristics. Such analysis will give a clear overview of what useful information the often very large amount of data collected is containing.

KJ-analysis starts with taking out interesting quotes and notes, one by one on a piece of paper, and sorting them into groups, either pre-defined headlines or topics that builds up during the session. These groups can be used for further analyses of the collected data. (Karlsson. 2005)

5.3. PHASE 3 : DEVELOPMENT

5.3.1. DESIGN FOR BOTTOM OF THE PYRAMID

Bottom of the pyramid is a term used for the world's poorest, the 4 billion people with a monthly income of less than 1000 Swedish kronor. One reason why this is an interesting market is the challenge of combining low cost, good quality with sustainability. It is according to Prahalad (2002) a market where it is not too late to introduce innovative sustainable development where developing and implementation of culturally sensitive, environmentally sustainable and economically profitable products and services can provide great change. (Prahalad 2002)

The bottom of the pyramid is now recognised as a just as good market as any other, but it is not a market that allows the traditional pursuit of high margins. Profits are instead driven by volume and capital efficiency. (Prahalad 2002)

Prahalad (2005) has developed some principles to use while designing for the bottom of the pyramid. The ones considered most useful in this project are:

- Focus on price performance – not just lowering the price
- Eco-friendly products – reduce, reuse, repair and recycle
- Design new products or do radical redesign – marginal changes to existing 'western' products will not often work
- Products must work in hostile environment – electric blackouts, dust, water pollution (Prahalad 2005)

5.3.2. IDEATION

A selection of well-known ideation methods has been used to support the creative process; brainstorming, sketching and model building, shortly described in Table 4, below.

5.3.3. PROS AND CONS EVALUATION

Pros and cons is a simple method for evaluation. All ideas get a list of pros, for, and a list of cons, against. This will help the researcher to get a clearer view and see the advantages and disadvantages of the evaluated ideas. The arguments, for and against, can be weighted, for example given score 1-5, to further help the decision-making.

5.3.4. ELIMINATION CHART

An elimination chart is a matrix where ideas are evaluated against important criteria. In its simplest version, the answer can only be yes or no, and the winner will be the one with most yes answers. In a slightly more advanced version, the criteria can be weighted and the achievement graded. (Johannesson 2004)

5.3.5. MORPHOLOGY CHART

Morphology chart is a method that helps the project to generate partial solutions on parts of the product. Functions or parts are put on the vertical axis of a matrix and the ideas, as words or sketches, are lined up horizontally in a matrix. The different ideas generated could then be combined into complete solutions, often after first being evaluated and tested. (Johannesson 2004)

Table 4: Short description of ideation methods

BRAINSTORMING	A tool to find creative ideas or solutions to a problem or given topic by quickly coming up with as many ideas as possible, either in a group or individually
SKETCHING	A simple tool to explore and visualise ideas, in two dimensions, with pen and paper
MODEL BUILDING	By building and creating three dimensional models it is possible to create, verify and evaluate shapes, functions and solutions as well as visualise the final concept

■ Introduction

Nonwoven protective garments are used in a variety of applications such as cleaning chemical facilities and contaminated areas, transportation of hazardous chemical goods, pest control, and asbestos abatement. The structure of the nonwoven materials used in such garments provides a high barrier function against penetration by dust, liquids or gases. However, it also limits the outward passage of body heat and moisture, resulting in moderate to hot climatic conditions against core temperature of the wearer. As a result, during strenuous activity and in conditions above the comfort level and in heat stress zone. These heat stress conditions lead to discomfort and fatigue and, in severe cases, risk the health and safety of the garment wearer. In addition, constant discomfort while wearing such

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Table 4. Average value of heat flux suggested

Vest	Average value of heat flux suggested
A	47
B	
M	

HEAT STRESS INDICES

temperature of 35°C).

The basic heat balance equation is:

$$\Delta S = (M - W) - (R - Q) \quad (eq. 1)$$

Where ΔS = change in body heat content; $(M - W)$ = net metabolic heat production (W); $(R - Q)$ = net radiative heat exchange; $(R - Q)$ = evaporative and convective heat loss.

This form defines the required evaporation to achieve thermal balance (E_{req}).

When body evaporative capacity of the environment is in excess of the required evaporation to achieve thermal balance (E_{req}), and thus, the maximal evaporative capacity of the environment (E_{max}) should be considered. The ratio E_{req}/E_{max} which denotes the required strain index (RSI) has been used to evaluate the scope of the present study.

The singular equation of the present study, several parameters should be considered. The ratio E_{req}/E_{max} which denotes the required strain index (RSI) has been used to evaluate the scope of the present study. The singular equation of the present study, several parameters should be considered. The ratio E_{req}/E_{max} which denotes the required strain index (RSI) has been used to evaluate the scope of the present study.

Table 1. The 6 key factors in determining thermal index

Factor	Index	Value	Unit
1. Dry-bulb temperature	T_{db}	35	°C
2. Radiant heat exposure	R_{net}	100	W/m ²
3. Wind velocity	V	1.5	m/s
4. Wet-bulb temperature	T_{wb}	25	°C
5. Metabolic rate	M	1000	W
6. Clothing insulation	I_{cl}	0.1	m ² °C/W

Notes: The conversion in this table are based on the following: 1. T_{db} = dry-bulb temperature; 2. R_{net} = radiant heat exposure; 3. V = wind velocity; 4. T_{wb} = wet-bulb temperature; 5. M = metabolic rate; 6. I_{cl} = clothing insulation.

PHASE 1 : PRE-STUDY

The Six Agents of Heat Stress

It follows from the heat balance equation that temperature per se is seldom the cause of heat stress, only one, and rarely the most important, of several factors that compose the term "heat stress". According to Fanger, the interactions of six fundamental factors define the human thermal environment and its sensation of thermal comfort. These parameters are subcategorized into environmental factors and behavioral factors. Environmental factors are temperature, radiant temperature, humidity, air velocity, and clothing insulation. Behavioral factors are the four basic environmental variables: metabolic rate and clothing (insulation and moisture characteristics) provide the behavioral variables. Human response to thermal environment and its consideration of thermal stress should explore these six factors.

Thermal Comfort

Thermal comfort is defined as "that condition of mind which expresses satisfaction with the thermal environment". It is a subjective response to the thermal environment. Metabolic rate, an

6. LITERATURE

6.1. LITERATURE : PROCESS

Data about the human body, hot environment and related topics were found in research reports, articles and books by searching for studies related to the performance in hot climates or hot indoor environments. These sources were often parts of either a study of work environment ergonomics or of build environment development.

6.2. LITERATURE : FINDINGS

6.2.1. CLIMATE

The environment can be hot or cold, wet or dry, calm or stormy, clear or cloudy, a mixture of them all and anything in-between. Due to that, heat negatively affects the body's ability to properly maintain itself. This project has focuses in hot environment in all its variations, especially in situations where it has a negative impact on people, living or working in it.

6.2.1.1. Climate zones

Four major climate zones (Figure 8), each with a distinct climate, cover the earth. These zones are generally belt-shaped and circular around the poles, but are sometimes affected by for example a mountain or ocean that gives clearly-defined but sometimes major difference in climate.

Tropical zones, latitudes from 0° - 23.5° at both sides of the equator, are where the solar radiation reaches the earth in a nearly vertically angle at noon all year round and makes it very warm. A high temperature also leads to increased evaporation of water and therefore the air is often moist.

Subtropical Zones, latitudes 23.5° - 40° , are the area that gets the highest radiation in summer when the angle at noon is nearly vertical to the earth and the cloud cover is relatively thin. It is less humid than the tropical zone, which increases the effect of radiation, and therefor most of the deserts in the world can be found in this zone. Winter in this region can be very cold and moist.

Also the tempered zones, latitudes 40° - 60° , are warm some months of the year, even though these zones normally are much colder than the tropics and sub-tropics. (Meteoblue 2012)

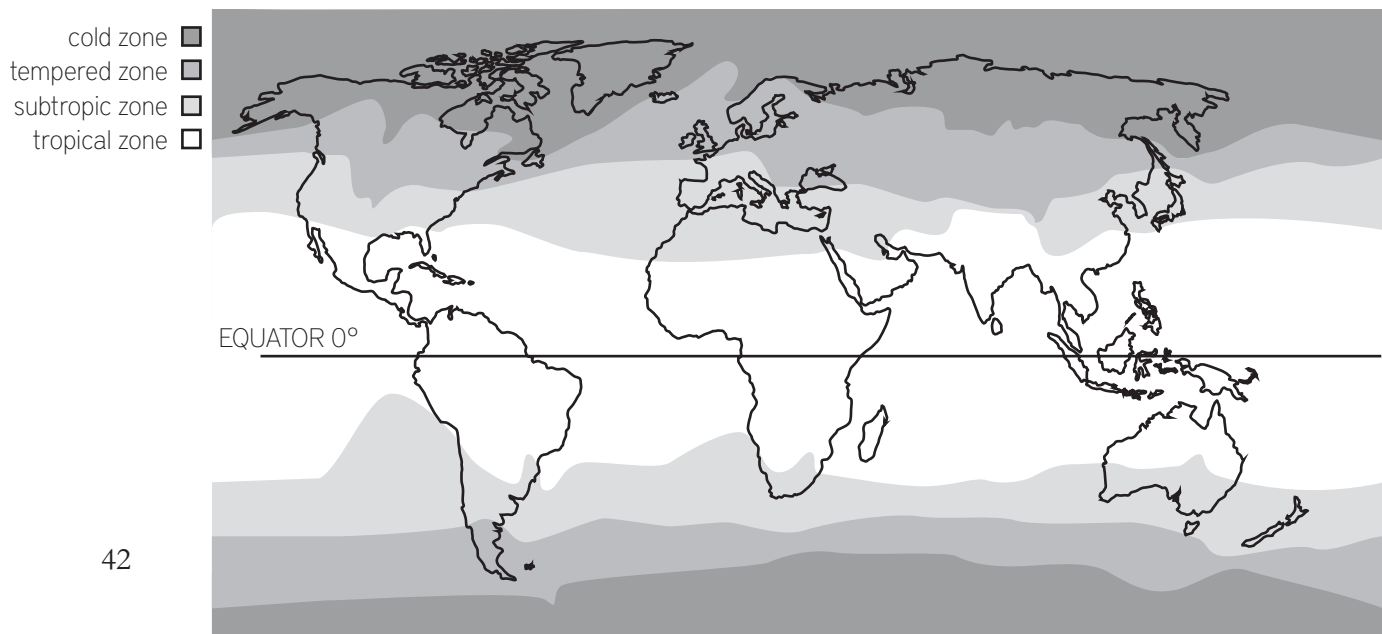
6.2.1.2. Global warming

The average temperature, near the surface of earth, has increased by approximately 0.6°C over the past one or two centuries. Global warming is the result of the greenhouse effect, the warmer surface on earth and a lower atmosphere. The greenhouse effect is caused by greenhouse gases, such as carbon dioxide and methane, which are increased by human activity. Effects of global warming, seen so far, are; rising sea levels, increased extinction of plants and increased extinction of animal species. (Britannica 2012-05-10)

6.2.1.3. Urban heat island

Urban heat island is the phenomenon of cities being a few degrees Celsius warmer than a related rural site at the same time. One reason is that urban masonry and asphalt absorbs, stores and re-radiates solar energy to a higher degree than vegetation and soil (Britannica, 2012-05-10). Another reason is that heat is thrown out of buildings by air-conditioning system and is generated by vehicles, factories and people.

Figure 8: Climate zones (Meteroblue 2012)



6.2.2. HEAT

6.2.2.1. Thermal environment

Thermal environment is what surrounds the body; the clothes worn, weather-related heat, cold and humidity, man-made heat and cold and exposure to solar radiation but also the air breathed and hot/cold food eaten. All these elements affect the heat transfer to and from the body.

Based on the relationship between environment temperature and human thermal balance, a living environment above 35°C and a working environment above 32°C is considered as high temperature environment. Humidity above 60 percent is considered a high humidity environment. (Zhao 2009)

Humans have a greater range of physiological adaptive responses to hot environment compared to cold environment (Greenleaf 1989). By combining both physiological and behavioural strategies humans can tolerate a vast range of thermal environments, and also have the ability to control the thermal environment by selecting appropriate clothing, heating and/or air-conditioning.

6.2.2.2. Body temperature

Humans are homeotherms and therefore attempt to maintain the internal core temperature within a narrow range of 37°C to not become ‘too hot’ or ‘too cold’. The body core temperature remains almost constant while the skin temperature is easily influenced by the environmental temperature and falls and rises to maintain the body’s core temperature (Kamijo 2006). Limits of survival occurs with a reduction of about 10°C or an elevation of 5°C. (Greenleaf 1989)

6.2.2.3. Thermal comfort

There are six environmental factors that affect the human thermal comfort. These are ambient temperature, humidity, metabolic rate, clothing insulation, radiant temperature and wind speed. The relation between the last five respectively and their impact on the experienced ambient temperature is explained in Table 5.

Table 5: Five environmental factors and their impact on the experienced ambient temperature

HUMIDITY	10% change in relative humidity can be offset by a 0.3°C in ambient temperature
METABOLIC RATE	An increase of 17.5 watt (above resting level) is equivalent to a 1°C increase in ambient temperature
CLOTHING INSULATION	1 Clo (the clothing insulation of thick covering work wear) change is equivalent to a change in 5°C at rest and 10°C while exercising
RADIANT TEMPERATURE	1°C change in radiant temperature can be offset by a 1°C in ambient temperature
WIND SPEED	0.1 m / sec change in wind speed is equivalent to a change in 0.5°C in ambient temperature (up to 1.5°C)

(Epstein 2006)

The American Society of Heating, Refrigerating and Air-Conditioning Engineers consider thermal comfort to be: “that condition of mind which expresses satisfaction with the thermal environment” (ASHRAE 2004). Thermal comfort for indoor climate is further defined by the same society as the temperature where 80 percent of sitting or slightly active people find the environment thermally acceptable. The acceptable ambient temperature is set to 23–27°C in summer and to 20–25°C in winter (Epstein 2006) in most western countries.

Fanger (1970) defined thermal comfort to be when the core temperature is held within the narrow range of 36.5–37.5°C, the skin moisture is low and mean skin temperature is within comfort limits (a skin temperature of 30°C at the extremities and 34–35°C at body stem and head). Deviation of any of these, results in discomfort (Epstein 2006).

Thermal comfort is also relying on non-environmental factors, which can be:

- Culture
- Climate
- Social adaption
- Psychological adaption
- Behavioural adaptations (Lin 2008)

Table 6: Symptoms of illnesses caused by heat stress

HEAT RASH	Skin irritation
HEAT CRAMPS	Muscle spasms and cramping
HEAT EXHAUSTION	Fatigue, headache, dizziness, nausea and weakness
HEAT STROKE	Confusion, delirium or unconsciousness, seizures, rapid breathing and pulse, hot, dry, red or flushed skin

6.2.2.4. Heat stress

Heat stress is a dangerous condition that affects people in hot environments, particularly those performing physical activities in hot and humid conditions, indoor or outdoor. Factors such as activity level, age, skin-to-weight ratio and hydration affect the speed at which heat stress conditions occur. Loss of body fluid and salt contributes to the heat stress. (Saner 2011)

Heat stress is most likely to happen in temperatures above 29°C and humidity levels above 30 percent. When temperature rises above 35°C and humidity increases to 60 percent it is a great danger for humans to work or do any physical activity (Saner 2011). Ways to reduce heat stress if found in “APPENDIX I”.

Heat stress is preventable and avoidable as long as the worker recognises the signs (Table 6) and takes precautions. Warning signs are for example headache, dizziness, unusual fatigue, nausea/vomiting and cramping (Saner 2011). Heat stress occurs when the body is redirecting blood from internal organs and muscles to the skin in an attempt to shed the heat.

A mild form of heat stress can cause irritability, decreased morale, increased anxiety, inability to concentrate and increase safety risks. Dehydration occurs when too much fluid is lost in sweating. (Saner 2011)

When the body no longer can keep the internal heat level, the reaction from the body is to pump even more blood to the skin. The heart pumps harder and the blood thickens due to fluid loss, which not only makes the human vulnerable to heat stress but also to heart attack. (Saner 2011)

Beyond the acute heat stress effects may be chronic heart damages and chronic kidney damages. (Greenleaf 1989)

(Smith-Horn 1998)

6.2.2.5. Heat balance

Heat is produced inside the body as a “by-product” of cellular metabolism and heat is also gained from the environment by conduction, convection and radiation (Greenleaf 1989).

The thermal balance is lost if the core temperature varies more than 2°C on either side of 37°C (Epstein 2006). The thermoregulatory mechanisms, coordinated by the hypothalamus, balance the heat loss and heat gain. When the heat production overcomes the heat dissipation the body’s core temperature will increase. Such an example could be if heavy work is carried out in hot and humid environment. (Kamijo 2006)

Tolerance to hot environment varies among individuals and depends on personal characteristics such as surface-to-volume ratios, body weight, physical training, tissue distributions and acclimatisation and sometimes also to age and gender. (Yao 2009)

Heat gain and loss

The first law of thermodynamics, the law of energy conservation, says that the total amount of energy within a closed system retains constant, but can be converted from one form to another. When humans are working or are physically active, stored chemical energy is converted into kinetic and thermal energy, with an efficiency of just above 20 percent. 80 percent of the energy will appear in the body as heat, and needs to be transferred into the external environment to maintain a body temperature of 37°C.

According to Saner (2011) the body can lose heat by radiation, convection, conduction and evaporation (Table 7). In colder environments almost 65percent of all body heat is lost through radiation (Saner 2011), while sweat that evaporates is the most efficient cooling in hot environments (Greenleaf 1989). An ambient temperature near or above 35°C and a relative humidity above 60 percent will hamper the effectiveness of all cooling mechanisms. (Taylor 2006)

Table 7: The heat lose mechanisms maximum percent of the heat loss

PERCENT OF HEAT LOSS		
RADIATION	65	Ceases to function when the air and skin temperatures equalize
CONVECTION	10	Ceases to function when the moving air is above 31-33°C
CONDUCTION	2	Ceases to function when there is nothing cool to be in contact with
EVAPORATION	Up to 100%	Up to 100% Ceases to function if the air is saturated with moisture or the body can’t produce more sweat

(Saner 2011)

Physical activity

Physical activities increase the body heat production. The amount of heat produced depends on the work being performed, age, sex, physical fitness and level of activity. (Harvard 2012)

A person of 65 kilograms that runs in a intensity equivalent to 135 watts (9.6 kilometre / hour) will generate 233 kilocalories after 30 minutes and would get a core temperature of 41.3°C if the heat had not dissipated from the body surface. (Kamijo 2006)

Human heat production is measured in the unit MET, where a relaxed, seated person has the metabolic rate 1 MET (1 MET = 58 W/m²). Other activities and corresponding MET values are presented in Table 8. (Harvard 2012)

6.2.2.6. Strain on active people in heat

Work or other activity in hot and humid environment, for a long time, is harmful to human health. It has both physiological and psychological effects on people that can lead to:

- Increased accident risk
- Increased irritability
- Reduced enthusiasm
- Declined excitability of nerve and muscle
- Lack of concentration
- Heat stored in the body even if the air temperature is not too high
- Diminished physical work capacity (reduce the productivity) (Zhao 2009)

The relationship between heat exposure and productivity has been analysed in a number of studies and the results show that heat exposure reduce performance, both physically and mentally in hot (indoor) environments (Kjellstrom 2009). Further, increased accident risk and impaired work performance may occur when the body core temperature exceeds 39°C (Saner 2011).

Table 8: Metabolic rate in MET for some activities

SEATED RELAXED	1.0
CAR DRIVING	1.4
STANDING, MEDIUM ACTIVITY (SHOP ASSISTANT, DOMESTIC WORK)	2.0
WASHING DISHES STANDING	2.5
DOMESTIC WORK - WASHING BY HAND AND IRONING (120 - 220 W)	2.9
BUILDING INDUSTRY - LOADING A WHEELBARROW WITH STONES	4.7
AGRICULTURE - DIGGING WITH A SPADE (24 LIFTS / MINUTE)	6.5
SPORTS - RUNNING IN 15 KM/H	9.5

(Harvard 2012)

6.2.2.7. Acclimatisation to heat

Acclimatization, improved heat adaption and elevated sweat secretion, is equivalent to lowering the ambient temperature (Greenleaf 1989). Acclimatisation is a gradual, long-term and reversible change (britannica 2012) that needs to be maintained with periodic re-exposure to heat to not be lost (Greenleaf 1989).

The acute phase of adaption to heat is often complete in 8-10 days (Greenleaf 1989), which is also the period when heat illness and work performance is most significant (Taylor 2006). Most of the acclimatisation is lost in seven days and the total loss is completed in less than four weeks.

Acclimatised people work in the heat with:

- Lower heart rates
- Lower skin and core temperatures
- More stable blood pressures
- Greater sweat rates
- Much less discomfort than they did before acclimatisation (Greenleaf 1989)

6.2.2.8. Personal cooling equipment

Personal cooling equipment can be divided into three groups, with respect to the functional cooling; air, liquid and phase change material. As portable or wearable options, only the phase change material is a good option, light enough and portable.

Studies have shown that an increase of 3 or 5 kilograms in cooling equipment increased the metabolism by 5 or 9 percent respectively (Duggan 1988).

A study where cooling products, similar to TST Sweden's Temptech products, were used during harvest work shows the effectiveness of cooling.

Result found in that study:

- With personal cooling equipment none out of twelve object's rectal temperature exceeded 28°C after 120 minutes work (without any cooling eight of twelve objects rectal temperature exceeded 38°C)
- A cooling vest reduced heat strain most effectively (compared to scarves or hats)
- The greater cooling area, the greater reduction on heat strain, rectal temperature and skin temperature
- Cooling gave no significant difference in heart rate during the session, but gave a quicker recovery during the following rest
- Personal cooling caused a reduction in total sweat rate
- None of the subject felts 'very uncomfortable' when wearing personal cooling equipment
- Trunk and neck were found to be most effective for cooling
- Non of these cooling products did not restrict the farmers' work (Choi 2007)

The maximum covered area was 770 square centimetres (about 4 percent average man that is approximately 2 square metres or 22000 square centimetres) of body skin area, in various locations on trunk, neck and head.

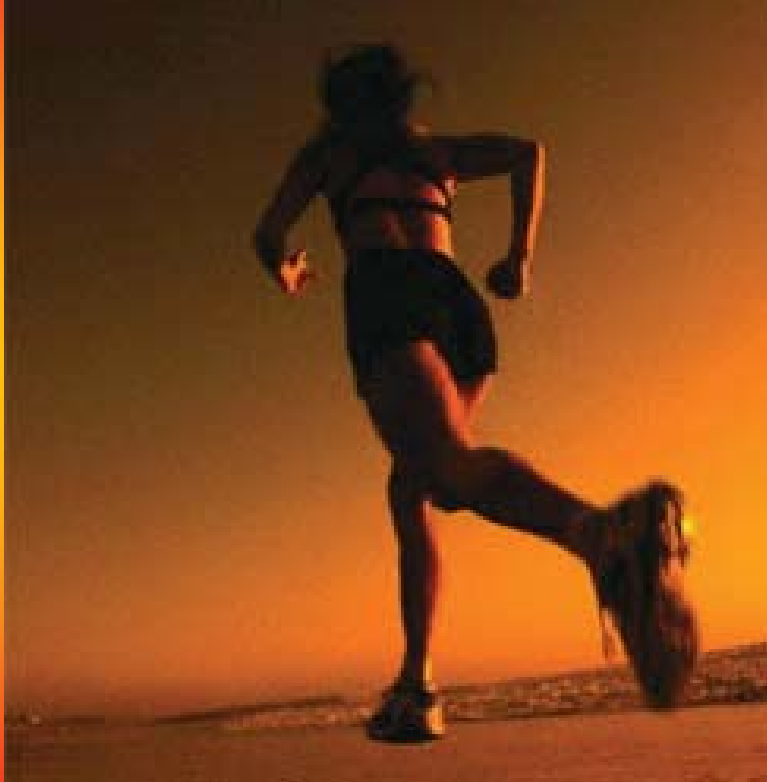
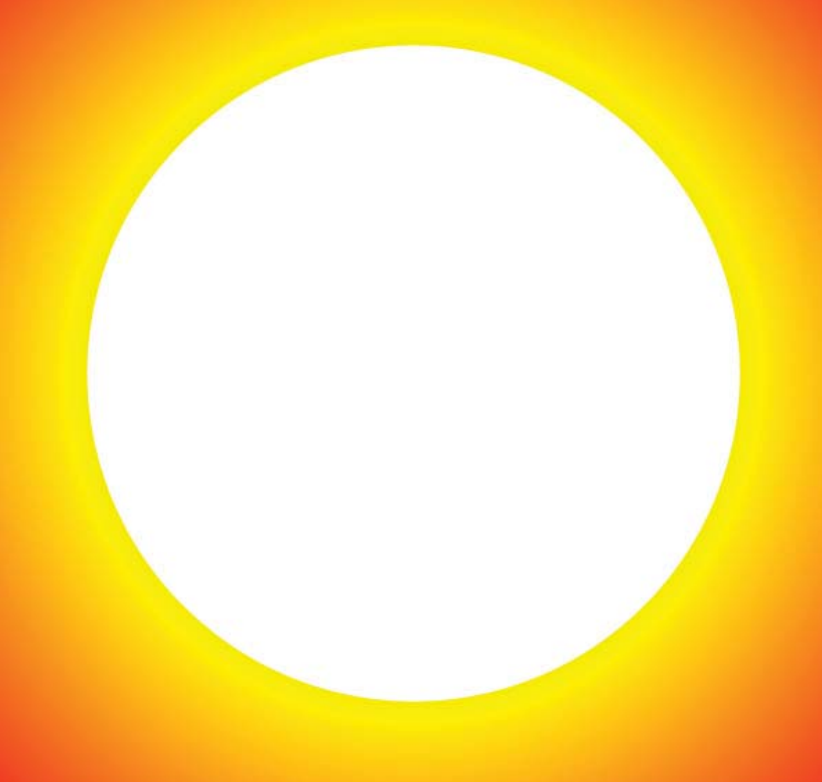
6.3. LITERATURE STUDY : SUMMATION

Many parts of the world have a warm climate, all year round both day and night. This makes the need of cooling urgent and as air-conditioning is not always a good option, other cooling technologies have a great opportunity to become one.

People staying in comfortable temperatures are healthier, have a higher overall well-being and decreased accident risk compared to people that are staying in too hot environment. A cooling product that helps the body temperature to stay within its comfort zone will therefore contribute both economical and social benefits to the people and society.

Image boards (Figure 9 and Figure 10) are used to summarise and communicate heat respective cooling, as found in the pre-study study, mainly the literature part. The heat image board shows the main source of heat - the sun – and additional heat sources, such as, exercising or physical active work, fire and vehicles. The cooling image board shows the main ways to help the body to stay cool; cold food and drinks, shade / shading and the importance of air movement.

Figure 9: Collage - Heat





7. MARKET RESEARCH

7.1. MARKET RESEARCH : PROCESS

7.1.1. SECONDARY SOURCES REVIEW

Only a few research articles were found on cooling equipment but more information were easily found in secondary sources and advertising about cooling products on the internet.

Secondary sources were searched for and reviewed early in the project to gain a deeper understanding for cooling products and the Temptech technology, and to find possible markets and potential users. Blogs, magazines and forums contributed interesting and useful information. The collected information was used as inspiration rather than findings that will be presented as result.

7.1.2. COMPETING PRODUCTS

Information gained in the market scan, all found in secondary sources, such as web shops and forums, on the internet, was analysed to find competitors. Secondary sources assisted the pre-study with useful and interesting knowledge to base the market research on and inspired the early planning of the field study. It provided the project with ideas of what kind of cooling product is preferred in what situation and what are the advantages and disadvantages with different kind of cooling products.

A competitor analysis was carried out to gain understanding of competing technologies. As this project will only work with Temptech element it was at the end decided to be of less interest, but the small analysis is found in “APPENDIX II” for anyone who wants to know more about other phase change technologies and their advantages and disadvantages, compared to the one used in Temptech.

7.2. MARKET RESEARCH : FINDINGS

The market for personal cooling products is huge and the amount of products sold is high. Cooling products without any need of electricity or battery are mainly of three types; body worn products that absorb heat (e.g. Cooling vests), products that prevent heat from spreading to the body (e.g. Laptop cooler) and products that absorb heat while the user is in contact with it (e.g. cooling seat).

Cooling products to wear are available for all parts of the body (Figure 11) and use a wide range of technologies. For upper body and torso, examples are cooling vests and cooling belts. For head cooling bandanas, hats and pads for helmets are found. Cooling scarves are often used to cool the neck. Many of these products cannot be used underneath a layer of cloths or in high humidity due to the technology used. The belt seen in figure eight is such a product, as are the wrist cooling. The only exceptions from this are the two Solvini products that are using Temptech elements.

Some companies are specialised on cooling for injured muscles and joints and sell cooling pads for different body areas. Technologies used are diverse but all use phase changes, either from solid to liquid or from liquid to vapour.

Other cooling products available are laptop cooler and cooling seat pads for car seat and chairs but also cooling mats (normally used for dogs) and cooling cases (normally used for medicine).

Figure 11: Competing products. From top left: Cooling hat (kula), ankle cooling (Cool CCA), arm cooling (Solvini), cooling vest, cooling scarves and wrist cooling (Ms Cooling), evaporative cooling belt and scarves, cooling mat for dog, leg cooling (Solvini)



7.3. MARKET RESEARCH : SUMMATION

Two things are common for all cooling products found to be useful in hot and humid climate: they are heavy, due to the main development is done for army, firemen and other fit men, and these products are often expensive. This means there is a gap on the market waiting for lightweight product with good cooling capacity to an affordable price.

There is no personal cooling product mainly developed for them who live and perform in tropical country (hot and with high humidity), have low income and where the electricity is scarce. This is a market where Temptech has great advantages, due to the use solid to liquid phase change, which makes it work as good in any humidity.





PHASE 2 : ETHNOGRAPHY

8. DEFINING POTENTIAL USERS

8.1. DEFINING POTENTIAL USERS : PROCESS

User centred design emphasis the idea of developing usable and understandable products and services. It always put the person, rather than the product at the centre and seeks information about users and their context.

People of interest in this project are those who want to, and need to, perform at a high level in hot environment. In the first two weeks of the field study a brief investigation of the broad group of potential users was completed, mainly by observing and converse people possessing useful and valuable information.

A selection of context and activity characteristics, estimated valuable for the further work, were looked into before the user groups could be defined. Many potential users where found in these environments. Similarities between different context and activities where looked upon and combined in various ways.

Examples of such characteristics are presented in Table 9.

Table 9: Further investigated hot situations

LOCATION	Country side / Urban
ACTIVITY LEVEL	High / Low
ENVIRONMENT	Indoor / Outdoor
WORK SECTOR	Service / Manufacturing / Agriculture
SALARY	Regular pay / Piecework

8.2. DEFINING POTENTIAL USERS : FINDINGS

8.2.1. POTENTIAL USERS : INDONESIANS PERFORMING IN TROPICAL CLIMATE

The defined potential users will be a diverse group of people. Weight has been on performing rather than leisure, because this is when the users are in the greatest need of a cooling device.

The group of potential users are defined to cover a larger amount of people, with broad experience of hot environment and with different socio-economical backgrounds. The project aims to develop a product that will be affordable to as many people as possible, which means an understanding of people with low income is very important.

Common characteristics for all users are that physical work or other activity is carried out in a thermal harmful hot/humid environment where air-conditioning is not an option. The group of potential users contain both indoor and outdoor workers, who perform both physical activities and sedentary work, in a wide range of work sectors and at home. These users cannot perform with full capacity without suffering. They are adult, of both genders and at physically fitness level from normal to very fit.

The group of potential users consists of people that have grown up and are now are living in a tropical climate that often or sometimes is too excessive for the human body. There was an early understanding that the hardest jobs, for example with high activity level or with high loads, are often combined with the worst heat situations, for example outdoor in sunlight or indoor without fan. Therefore these jobs are not what people, with an option, want to work with, but what is left for them without any other way to earn their living.

These users are chosen to be of highest interest because of numerous reasons. Major reasons are that it is high time to introduce resource efficient cooling equipment on the Indonesian market; that people working in the most excessive heat often are among the poorer; and a large amount of people are working in hot environment every day.

8.2.1.1. Active

A situation where a person is performing physical activity will, in any environment, be warmer than a situation where a person is resting. This due to that the physical activity increase the amount of metabolic heat produced in the body.

The active situations can be found both outdoors and indoors, and at any level of activity and as long as it is hot and harmful it will be of interest for this study.

Potential users can be constructions workers, agricultural workers, housewives, sales (wo)men, medical workers, cleaners, garbage collectors, sales (wo)men waitresses and many other.

8.2.1.2. Sedentary and stationary

A sedentary or stationary situation in this project is thought of as a situation where minimal or almost none physical activity is carried out. It can either be an actual work situation or the resting time after activity when the body should recover. Despite no extra metabolic heat is produced this situation is hot because of the climate or architecture style.

The sedentary and harmful situation can be found both outdoor and indoor, where an indoor environment with insufficient ventilation could be as bad as an outdoor environment in sun.

Users in this environment can be security people, shop assistants, chauffeurs and taxi drivers, factory workers, traffic guards, tour guides, receptionists and other.

8.2.2. DATA COLLECTION

This broad user group will be investigated with an ethnographic field study. Observations and interviews are chosen as main methods, but are complemented in various ways to gain a deeper understanding not only for the heat but also the country, its culture and above all its inhabitants.

The understanding of who should be included in the study, as participants, will be based on the information looked for in the different stages. Participants should be chosen to gain a deeper understanding of the user needs and interests in a cooling device and next to understand the culture and context that these people live in and the product will be adapted for. The knowledge found by investigating this user group will be the foundation that makes it possible to develop a product that has potential to become an environmentally friendly and economically beneficial competitor to these potential users and at the same time is a product that in a nice and simple way lessen the strain on the human body that comes with performance in excessive heat.

A cooling product adapted for this user group, will not just have a great potential to become a real product in the future but will also be suitable for a much larger group of people, not deeper investigated in this study but in urgent need of effective cooling.

Naturally, there is no obstacle that the product developed in this project will be suitable for many other people than the one covered in the defined user groups.





TRADE MARK
BINTANG
PILSENER

Mentaw
Mentaw
Mentaw

TEMPERATUR LIK





8.3. DIFINITION OF USER GROUP : SUMMATION

A selection of potential users and work situations are shown in Figure 12.



Figure 12: Selection of potential users

9.1. ETHNOGRAPHY : PROCESS

The field study was conducted as a small ethnographic research where heat, in an Indonesian context, where investigated with an open mind and few boundaries, especially in its early part. The ethnographic data that was searched for should cover the physical context of a hot tropical environment and the personal experience of heat told by the people living and working in this specific environment, country and culture. An early planning, sent to the university of Surabaya that assisted the project is found in Appendix III : Ethnography planning.

The first aim for the ethnographic data collection was to find information of where a TempTech cooling product is most needed, in what situation it would be beneficial to use and who is requesting such product. The second aim of the ethnographic study was to understand these potential users and their situations and make sure the data needed for the later development part was collected and reliable.

The ethnographic research was carried out by a combination of tools, mostly observations and interviews. Additionally an assessment worksheet, developed for this project, where found to be an interesting complement. Difficulties with language and cultural differences were taken into account while planning the ethnographic study, but where the language became a much larger hamper than calculated for, the local hospitality, assisted the work.

The ethnography study was split in three parts: the early, the latter and an overall. The overall should be seen as a complement to the two first, structured parts, and was mainly a resource of confirming what were asked, seen or told in the two first parts.

The early part took part in Surabaya, Jawa, which is the second largest city in Indonesia on the same island as the capital, Jakarta. It is an industrial urban area built relatively close to the sea and with high density of people. The temperature is high, often above 30°C also in the late night but a bit lower in the early mornings.

The latter part took part in two different parts of Indonesia, on Batam Island outside Sumatra, and on

Bali. The researcher lived for a few days in two different homes; Sara's family house in a city on Batam and Adi's shared house on the countryside of Bali.

The overall part is the small discussions and everyday observations that was not planned or structured but deepened the overall understanding of Indonesia, Indonesians and the culture. This was what happened when nearly three months is spent in the research environment and with and topic as usual and easy discussed openly as heat.

The main participants are presented in Table 10, Table 11 and Table 12.

Table 10: List of participants in the early part

	INTERVIEW	OBSERVATION	WORKSHEET
STUDENTS SURABAYA UNIVERSITAS	E		
JUNAIDA - HOUSEHOLD CHORES	B	X	
WANGI - TEACHER	E		
AGUNG - WORKMAN	B	X	

B = Bahasa Indonesian, E = English,

Table 11: List of participants in the latter part

	INTERVIEW	OBSERVATION	WORKSHEET
SARA - HOUSEHOLD CHORES	B	X	X
ADI - DRIVER / TOUR GUIDE	E	X	X
FRIDA - DOCTOR	S		
ANNA - GRADUATE IN MEDICINE	S		
ANITA – NURSE	B		X
HALIM - DOCTOR	E		

B = Bahasa Indonesian, E = English, S = Swedish

Table 12: List of participants in the overall part

	INTERVIEW	OBSERVATION	WORKSHEET
INSPIRING AND TALKATIVE PEOPLE	B + E	X	X

B = Bahasa Indonesian, E = English

9.1.1. OBSERVATIONS

9.1.1.1. Early part

Observations were a very important part in the early part of the study, when user groups and usage situations were yet to be defined. It was important for the researcher to see and explore both everyday life and working situations to be able to formulate an interview template adapted for Indonesians participants.

9.1.1.2. Latter part

The planned and organised observations have been of two kinds; as a complement to interviews and as long time participating observation. The structured long time observations took place in two homes where the researcher was invited to stay while collecting data and interviewing.

In the latter case, the observations were rather used to find new topics for discussions than for direct data collection. The main reason was that it in these cases were possible to follow up and confirm thoughts and interpretations, which were often not accessible at the same level at the everyday life situations observed in the beginning of the study.

9.1.1.3. Overall

A decent amount of data comes from observations of daily life, things seen on the way to an interview or walks at night. Observation data was in these cases written down and / or photographed.

9.1.2. INTERVIEWS

9.1.2.1. Early part

Interviews in the early part of the study were either unstructured with people met randomly or semi-structured with people booked for an interview. An interview template ("APPENDIX IV") was developed, based partly on these meetings and partly on the findings in the pre-study. The template was followed in three of the interviews; the housewife, teacher and workman.

A focus group, or closer to an open session, meeting was held on the Universitas Surabaya at the department of engineering design. Students, teachers and the head of the department were participating. In this session students had been informed on the topic and prepared information and photographs from their own thesis work that could be useful in this project. The student work was based on interviews and observations, for example with farm and factory workers.

9.1.2.2. Latter part

This part of the study had to collect a deeper understanding for the user, context and situations where the cooling device could and should be used. Therefore the strategy was different than in the early data collection part. Interviews in this part were less about tropical heat and more about the impact and experience of it, often in one or a few specific situations rather than as everyday life scenarios.

Two interviewees were deeply investigated, with an initial semi-structured interview followed by several smaller discussions of observed behaviour or activities. It was possible thanks to the invitation to live in their homes for a few days.

Two Indonesian medical workers were booked for in-depth interviews, of which the nurse with her own village health practice, provided most useful information. None of the places where these two actually work were observed but another similar practice was.

In-depth interviews were held with two Swedish medical workers that both recently have been working in Indonesia. The reason was to get their point of view on the combination of medical work and the Indonesian heat.

9.1.2.3. Overall

Discussion and small talks with people met randomly were used to confirm and better understand findings from interviews and observations, as well as a great source of inspiration.

9.1.3. ASSESSMENT WORKSHEET

9.1.3.1. Latter part

An assessment worksheet (Figure 13 or in full size in “APPENDIX V”) was developed, based on the information from early interviews and pre-study findings, as a complementary tool. It was used to unify the interviewee and interviewer on a common base. The worksheet was also used as a mediating object in discussions and interviews.

The assessment worksheet was used to increase the reliability of the result, which could be problematic in cross-cultural studies. One such understanding, of unconscious apprehensions that varies wide among people, is the definition of cold; is it cold when it is 24 degrees and one person is freezing and another person is sweating? The answer does not matter as long as the interviewer and the interviewee understands each other and talk about the same thing.

Assessment worksheets were filled in by the two main participants, Adi and Sara, and also by a few of their relatives. In the latter situation the assessment worksheet was advantageously used as a mediating object for better discussion with randomly met people that were talked to.

9.1.4. KJ - ANALYSIS

KJ-analysis was used to distil the useful bits of knowledge from the collected data. The data collection during the field study had resulted in a large amount of narrative data, not all relevant to this project but often very inspiring in other ways. Data of value for further work has been organized and analysed.

The KJ-analysis started with sorting of notes and quotes in a way that made groups emerge. Some of them more relevant than others, and once again data slightly of topic could be recognised and taken away from the groups that would form the result.

Figure 13: Assessment worksheet

9.2. ETHNOGRAPHY : FINDINGS PART 1

Despite the broad field of research and the diverse group of people interviewed and observed, the collected data is not specific for one person, one user group, one situation or one environment but together gives a wide understanding of Indonesians heat experience and the Indonesian context.

Common information, found in many situations and by different research methods are presented as the main result in Ethnography : findings part 1, while the three more in-depth investigated participants also are presented as one scenario each, in Ethnographic : findings part 2.

9.2.1. HEALTH ISSUES IN HOT ENVIRONMENT

Not a single one of the interviewed is by the first thought assessing heat as a potential danger for the human body or well-being. Some mentions that the sun is dangerous for the skin because of cancer risk. But while discussing other topics it is mentioned that hot environment gives people headache, make them very tired and slow in thinking. It is also mentioned a few time that it affect the temper of people, someone says that heat takes the smile away from the face while other mention irritation, bad emotional control and stress as result of too warm environment.

People working and living in artificially cooled buildings consider the heat to be more of a problem than people living and working in the heat everyday. The heat is sometimes assessed as a bigger problem for them not used to it and sometimes said to be very much depending on the individual.

But for all people requested, it is an excessive heat for long time respondents are talking about when heat related problems are mentioned, not an hour or two relaxing in the shade even if temperature is higher than 30°C.

9.2.1.1. Indonesian health care

Indonesian hospitals are rarely, then only partly, equipped with air-conditioning, but more often with fans and large window to open. This does not include the outdoor area where the ill are waiting. The waiting 'room' is often outdoors in the heat where only the luckiest will be able to find shading. It is not unusual

that patients have to wait very long, sometimes not only hours but days, for treatment, also when an appointment is booked. It is also common that all family members follow a sick relative to the hospital or clinic, which means it is not only the many sick waiting in the hot sun all day but also their company. It is therefore not uncommon that the first treated illness is heat related, such as heat rash or dehydration, says the doctors spoken to.

In Indonesia every person have to pay for their health care themselves, which means the doctors can only give the treatment she or he knows the patient can pay for, and nothing is wasted – not even the disposable gloves.

Hospitals are located in cities and not found in the rural areas. The less populated the area is the greater is often the distance to a doctor. Instead every village, at least the slightly bigger ones, has a nurse that can treat the more simple and common illnesses and health problems. Such a nurse has university education and does similar, but slightly more advanced work than a Swedish nurse, for example is this nurse also a midwife and can do some simple surgeries, according to what the researcher understands. A nurse in a village often uses her or his own home as health clinic. The nurse talked to in this study, Anita, had air-conditioning in her home. This gives her a nice working temperature as long as the patient is strong enough to come to her place, but she says that she often does home visits, and then she is sometimes feeling too warm. She dresses in her own clothes but also put a coat on top, similar to the one a doctor have.

All medical workers talked to said that the Indonesian climate could be a very tough environment to be sick in, both because it is warm and because it is humid. Bacteria grow quickly and patients are often sweaty and warm, which all make it harder to recover.

9.2.2. HEAT

9.2.2.1. Thoughts about Indonesian weather

Weather affects daily activities, particularly work. Worst is the heat, according to interviewees, but rain is often mentioned with negative words too. Rain is talked about as something that makes activities stop, because of the flooding that it results in, while heat is talked about as something you have to live with and continue working in. Sunny and warm days, are testified by interviewees, to result in slower level of activity, but also unpleasant sweat that makes people uneasy and stinky. Hot temperatures make many people uncomfortable, while others can stand it quite well. Some people talked to is of the opinion that if they are happy and in good health the ambient temperature is not bothering them too much.

Inland parts of the country, if not mountain areas, are more or less warm all year round, both day and nighttime and so are urban areas where the majority of the Indonesians live. City life is often a never-ending struggle against the sun, its heat and the sweating that comes with it.

Indonesians like warm temperatures, but not scorching heat as in direct sunlight. The preferred environment is relatively warm, in the shade and with air movement, for example a nice breeze or a big fan. Not many of the interviewees have experienced temperatures below 15°C, or even 20°C, which is the temperature mentioned as 'very cold', especially if combined with shade, wind or rain.

At first though the Indonesian respondents think of the sun in one of two ways; scorching heat and brown skin or food growing and free electricity. Forest fires, drought and cancer are also mentioned when talking about solar radiation. Most Indonesians try very hard to never be in the sun, other have no option but to work full days in a sunny environment. It is of highest priority to stay out of the sun and covering cloth is an option while it is not possible to avoid. The main reason is to keep the skin as white as possible, which is by others interpreted as a wealthier person while brown skin is interpreted as if the person is poor.

9.2.2.2. Warm situations

When asking for uncomfortable situations, which are related to heat, a few are mentioned more often than others. The situations found are listed below. The list begins with the situations most often mentioned and ends with the one more seldom heard or seen.

- In the sun / No shade
- Outdoors without air movement
- Indoors without air movement or air-conditioning
- Too small fan
- Working
- Walking
- Vehicle that has been waiting in the sun
- Waiting (for public transport, queuing)
- In crowded public transport
- In traffic jam, slow driving or at stop sign
- Exercising and after high pace activity
- Cooking
- Sleeping
- Eating
- Drinking
- Crowded places
- Too much clothes
- Close to warm machines and computers

9.2.2.3. Warm part of body

The whole body gets warm, but arms and leg not often as bad as the torso, according to the interviewees. The back is often the worst, from upper leg to neck, but it depends on the activity and posture. Regardless the situation and outer impact, middle part of the body is said to be warm if any other part is warm and so is the face.

Other parts mentioned to be in great need of cooling are listed below:

- Body parts touching equipment get warm, for example when seated in a chair, the back or your upper leg and your back will get very warm
- Body parts close to or touching other people get very warm, for example in public transport
- Body parts touching each other makes it warmer, for example inner thighs
- Sweat makes the heat worse, not that it feels warmer but that it becomes a greater burden
- Parts of the body covered by clothes, a bag or other carried equipment get warm while parts with free air movement might stay at a cooler temperature
- Neck gets warm if the hair is loose or a scarf is covering

9.2.3. COOLING

9.2.3.1. How to beat the heat

Heat is by most of the respondents not seen as a problem you can beat, but as a part of the everyday life that will always be there and you have to learn to live with. Therefore it was often hard to get people to talk about precise things they do to stay cool, because it is done without thinking and planning, or is assessed as an uninteresting thing to tell. The ability to cope with the heat on daily basis is on the other hand deeply rooted in the local culture and often there is no conscious strategy for preventing body heat damage.

Shade

First of all, to stay cool - stay in the shade. This advice comes from most of the interviewed. Further they say that if it is not possible to find shade, at least try to shade the body by using an umbrella or hat.

Air movement

Windy days and places with a nice sea breeze make the life easier for many people. If this is not the situation a folded fan is often used by girls and women, while boys and men choose to use a piece of paper or similar for the same purpose. Fan is an option where electricity is available.

If it can be afforded rooms should be built with high ceiling, Sara said, because it makes the house colder. The same with a second floor, which also has better air movement and fresher air, according to some interviewees.

Slow down

Slow down or take a rest was another common advice and the researcher is often told that she walks too fast and too much to ever stay cool.

Water and ice

It is also often stated that a shower is very nice way to cool down, or a swim in the sea, river or a pool. It is observed that ice cubes are requested from drink sellers and hold against the wrist and face to make the body cooler.

Clothes

Covering clothing is warm. Fewer pieces of clothes or less covered area of skin are said and observed to be good for cooling. Men can for example often be seen without t-shirt or with their t-shirt lifted to open up for free air around the torso. Girls and women almost never do the same in Indonesia, at least not in Muslim parts or if they are Muslims themselves.

9.2.4. PHYSICAL ENVIRONMENT

Interviewees execute their daily activity or work in a tropical climate zone, where day temperature often is higher than the upper limit for work environment in other, often western, countries. Environmental conditions in many workplaces and homes are set by the weather conditions rather than in control by the people themselves. For example if it is not a windy day there won't be any cooling air-movement present. Due to outdoor work or the modern architecture styles in Indonesia the weather impacts on daily living and work are predominant.

9.2.4.1. Artificial cooling

One experience of cold, both natural and artificial, told by many Indonesians, is that cold makes people sick and the muscle sore. The same people think air-conditioning is too cold and do not want to spend long time in artificially cooled air, but say they sometimes go inside an air-conditioned room to cool down.

Other talks about ATM-stalls and shopping malls as very nice places to stay for a while, just because these places have air-conditioning. It is also learned on a new bus route, free the first month, that the main reason for travelling is because it is nice and cool, a bit too cold, but still much better temperature than outside. The trip this was told on was taking part a normal warm day in Bali.

9.2.4.2. Cooling products

No one has heard of other cooling product except air-conditioning and fan, and especially no cooling product that does not require any electricity. Folding fans and ice cubes are not mentioned as cooling products, but observed in use very often.

9.2.4.3. Built environment

Built environment in Indonesia covers everything from a simple shading roof to skyscrapers. A house should be a protection against different weather conditions, such as sun, rain and wind. Built environment in Indonesia has no sharp line between what is indoors and what is outdoors, as well as no rule for what kind of building that can be provided with electricity. A simple roof shading can be equipped

with electricity that makes it possible to have a fridge and a fan, while a house with four walls, windows and a door might not have any electricity.

Architecture style

The simplest and cheapest construction for shading or housing is built in bamboo, with wicker walls and a thatched shelter. Homes can be combined with the family business, such as a restaurant or shop.

Traditional houses were built in wood, bamboo and palm tree leaves. It had one room, raised above ground level, for the family to share. Area for cooking and toilet were located outside the main building. This style of house is still found on the countryside and is popular because it is long lasting. This kind of housing provides a nice thermal environment, and has traditionally been a better and cheaper option than concrete or brick houses.

Modern buildings have fundament and supporting walls of bricks and concrete and are covered by a flat roof. These buildings are often dark and have problem with the airflow. Mould is another common problem, as are the lack of maintenance and the poor initial quality. This is the type of housing that is mainly built today in Indonesia, some with better quality than other. This type of building is today cheaper than a wooden house in the same size and quality.

Electricity supply

It is common that the electric supply is just enough for a few hours everyday and not very reliable at all. Even in wealthier quarters of big cities, the electricity is off sometimes as much as a few hours every week, but that's nothing compared to the countryside, according to interviewees.

Electricity is not available on all locations and to all families, often because of economic reasons and poor overall infrastructure. A way to get round the expense of installing an outlet is when families, two or more, get together and share one outlet. It is not legal, but a way for more people to afford some lights, a fan or a small TV for example.

9.2.5. SOCIAL ENVIRONMENT

Work is important for most Indonesians, so is a place to sleep, the belief in God comes next and for survival it is good to get some food, at least once a day. Cigarettes are, unfortunately, mentioned quite often as a main thing for survival too. This list is a combination of what people talked to have said and what is seen during the study.

Hurry and stress are not often seen in the Indonesian culture. The opinion is that if you have to wait for something, why not talk to the person next to you and you might find a new friend or business contact. In Indonesia the family is very important. It is together with the family that festivals such as Eid al-fitr (festive season after Ramadan) are celebrated. It is more common today that young people have to leave their family village to find job in other parts and on other islands of the country.

People live in the present, and listen to the body. Indonesian eat when they are hungry, not at certain time or certain times a day. Yesterday, last month or last year is sometimes used just randomly for some people, because it is of less interest, it happened in the past and that's it. This might differ if for example people with a higher education and different life style had been interviewed.

9.2.5.1. Dining

All meals are served more or less warm. Breakfast favourites are fried noodle and chicken / fish soup. For other meals of the day the traditional rice-buffet in different styles is served. Despite what island it origin from, the buffet will contain many different dishes; vegetable, noodles, fish and chicken, but also crackers, potato cakes, spring rolls and more again.

Drink is served warm; coffee, tea or hot fruit juices. Of course many Indonesians drink cold drinks as well, but hot is often both the favourite and the cheapest option.

9.2.6. WORK

Not only low-qualified workers are daily performing their job in the sun, although their jobs are more often located in the sun. Farmers and construction workers are often in the sun, so are the traffic and security guards. Although, the higher status the job has and better paid it is, the greater the chance that the workers have somewhere to stay protected from the heat, at least for the resting times.

9.2.6.1. Work Environment

Job location differs, but generally there is a better chance to earn money is where people live, which makes people move to for example urbanised areas.

Heat is a part of many Indonesians work environment. A specific environment that interviewees consider bad, sometimes even worse than direct sun, is the one inside barns, or similar big houses, with thin tin roofs. Factories and other closed building are also often described to be an environment that is very hard to work in, at least when heat is considered.

Fans make the surrounding temperature more bearable and the air fresher, but have its own problems. It is noisy, and if it is not big enough it will not be able to give all worker good temperature while the one standing to close will suffer from the draft.

An example of hot work environment is farming, which is a hard job, often carried out in high temperature. To mitigate the situation for worker on the field small huts are used to give shading during rest periods. Also the work is often for half days, from early morning to one o'clock. For a worker on the rice field an additive heat problem is that the shallow water covering the field gets warm in the heat, which heats the worker also from underneath.

Outdoor workers are suffering in the heat, but a few states that as long they are able to rest in a shady and slightly windy place as often as needed it is hard but can be ok. The resting time is often not enough though, because it do not provide a cooler temperature but only a slower pace.



Performance in heat

Heat is described as a problem when it comes to the level of work performance that can be achieved, but not something talked about very easy. For most interviewees the idea of the work performance in heat is that you have to slow down, take rest and be patient. “No hurry no worry”, as Agung says.

People that work in hot factory think that it is a problem that the owner want them to work harder but does not provide comfortable work temperature, some places have not got a fan, other have problem to get fresh air into the building. This was all told by a

student, from Universitas Surabaya, that investigated the work in a cake factory last semester.

One woman met on the street said that there is big difference between how people stand the heat. For example she says that: “At the time other start dying, that is when I start to suffer”. She says that there are people that have really big problem to cope with the heat, but points out more than once that she is used to it and will always work hard, no matter what circumstances. This lady has been working on the field all her life, both in Indonesia and abroad.



Salary

Indonesia is an emerging country, a developing democracy where head of department lately has been sent to jail for corruption, but it is a nation where rich become richer and poor stay poor. These facts are both told and read in newspaper.

Minimum salary is around 800 Swedish kronor (1 000 000 rupiah, as 1 Swedish krona is 1 200 rupiah) but many people have to survive on less than half of it at the same time that an educated person can get many times more.

A worker performing a heavy job, where the temperature is too warm and the salary too low, often has a background in a low socio-economic group and only a few years educational background. The same work-

ers are often governed by managers and customers demand and can often not adjust their work hours or work intensity themselves. Lowered working capacity will in many cases mainly affects the workers themselves, for example by loss of income or harder to get another employment in the future.

An interviewee told that a day's work on a rice field, from 7am to 1pm, gives between 10 000-15000 rupiah, which about 10 Swedish kronor, but thankfully a simple lunch and some cigarettes are often included.

Minimum prices on some common things when bought in Indonesia are presented in Table 13.

Table 13: Example of Indonesian prices (Rupiah = Rp and Swedish krona = SEK)

RICE (1 KILOGRAM)	9 600 Rp	8 SEK
MEAL RESTAURANT (VEGETARIAN)	7000 Rp	5.80 SEK
MEAL RESTAURANT (WITH MEAT)	15000 Rp	12.5 SEK
1 MIN. OF PREPAID MOBILE TARIFF LOCAL	1000 Rp	0.8 SEK
ONE WAY TICKET LOCAL TRANSPORT	3000 Rp	2.5 SEK
GASOLINE (1 LITRE)	4500 Rp	3.3 SEK
MOTORBIKE (NEW HONDA)	17 000 000 Rp	14 200 SEK
MOTORBIKE (SECOND HAND FROM 2008)	7 500 000 Rp	6 250 SEK
PACK OF CIGARETTES (MARLBORO)	1 300 Rp	10.80 SEK

9.2.7. CLOTHING

In the city the clothing seen on young people can be very similar to what is seen at summertime in Sweden, even if often slightly more covering. Light coloured clothes are preferred in respect to stay cool while darker clothes are chosen as the more durable.

Indonesian clothing depends on traditions and culture rather than the weather, as well as it may depend on what garments are actually owned rather than what is preferred to be used. Traditional Indonesian clothing is for example batik sarongs. Such clothing could be used anytime, for example at work.

People, especially women, working outdoor and partly in the sun are often dressed in many layers, thick ones too, and can be seen wearing socks in their thongs. Outdoor workers almost always cover their head with a hat or cap, which is sometimes combined with a shading scarf covering the neck.

Many professions have uniforms, similar to a suit, combined with formal shoes. For a man this means long dark trousers, shirt and suit jacket and for women it means a long skirt, shirt and suit jacket. Headscarf is worn by approximately 50 percent of all women seen during the ethnographic study and is used to a higher degree in suburbs and rural areas than in city centre and the university area.

Men cover the skin to not get tanned. Women do the same, but for them it might also be a question of following religious recommendations. It is understood that the sun is the first reason for covering and traditions, not only religion, is the second. The majority of the women choose to cover shoulders and knees. Older women is often seen in full lengths skirts and long-sleeved jumpers.



9.2.8. SUSTAINABLE DEVELOPMENT

A few materials are now collected and recycled in Indonesia, but the overall level of knowledge about the environment and sustainability in the society is low. Rubbish is left wherever it is easy, on the ground quite often. The good thing is that the government pay a small amount of money per kilogram waste of some sort that makes it quite attractive to collect, at least for the very poor, this works for plastic bottles and similar but leaves smaller pieces and thin plastic bag behind, due to the negligible weight.

Cities in Indonesia has often very bad air quality with pollution from the many motorbikes, cars and factories crowded on a relatively small area. Another obvious thing is all the rubbish covering both cities and villages.

A good thing is that eatable things are not wasted in the same way as it is in other countries; all part of the animal is food and all part of the plant is useful in some way. Unfortunately, a growing wealthy middle class Indonesia might change this and behave in an other way.

Sustainable development, a topic not often thought about on the countryside, but more present in different ways in the government, the major cities and the tourist areas. The government are involved in many worldwide sustainability programs but has not yet found the finances that is needed.



9.3. ETHNOGRAPHY : FINDINGS PART 2

The second part of findings contains three short stories – a day in life scenarios. The first one is a story combined from two interviews, one with Frida and one with Anna. The other two stories are based on the observations, interviews and discussions that took part during the researcher's stay in the homes of Sara and Adi.

9.3.1. DOCTOR FOR A DAY – FRIDA

Frida puts the doctor's coat on top of her normal clothes and is ready to leave the house for another day at the countryside hospital. This is a routine she has embraced since arriving to Indonesia, and that she is not quite happy with, because then she does not feel fresh when entering the first patient after the half hour's journey. But her colleagues are picking her up, and they all dress in their coats before leaving so she has decided to do the same. She dresses in long skirt, covering thin and long-sleeved t-shirt and covering shoes. The rule says that the arms and legs have to be covered, so there is no option to wear a top or t-shirt under the coat. It is warm, and she can feel the sweat running down her spine a few times every day.

Frida has been in Indonesia for a few months now, working as a specialist doctor. She loves the people, her job and her colleagues, which are all very skilled. Especially, she is impressed of the job they can do with the very simple equipment and overall conditions that are the fact.

Organisational routines at the hospital is generally very similar to the one Frida is used to but the hygienic routines are not. In the hospital she knows only one about sink where the water is working and the soap is not finished. This is where she sometimes, when it is way too warm and sweaty, runs off to and wash her face in cold water, but it is too far away to be used for normal hygiene routines. Instead Frida carries hand disinfection with her all the time, to make sure she not spread any bacteria.

The indoor area, where most work is carried out, is warm but the windows are open and fans are used so it is ok most of the time and if the pace is slow, which it kind of is. But she would be able to work better and harder if it was just a few degrees colder. Most of the patients would also benefit from a cooler environment, tempered beds or blankets or cooler

waiting area. Many patients are waiting for a long time outside and not all can be fitted in to shady places which means one of the most common first diagnosis are dehydration and heat related illnesses.

Frida did not speak any Bahasa Indonesia (the Indonesian main language) when she arrived but has learned quite a lot now. It is good to be able to understand the patients better, not as important when it comes to the colleagues because some of them speaks English and the medical language is built on Latin, which means both diagnoses and treatment are understood anyway.

The afternoon hours are the worst, it is hotter, more patients are often waiting and the already worked hours in the heat are making themselves known. Frida often has a little headache and is exhausted the last few hours of work every day. But she knows that the patients' needs are more urgent, which means her personal needs are sometimes neglected. She is used to work very hard, but in good conditions that support her work, and therefore the Indonesian health care gives her a hard time and it has taken some time to get adapted to the new situation, where the need is great but the possibilities small. And it is hard to accept that she cannot always do as good as she could in other conditions, but she will always try.

After a long day at the hospital, Frida normally heads back to her room, takes a long cool shower and sleeps for an hour or two. Then, when the sun has been away for a while, the worst heat has faded away she is ready to go out again. She normally goes with friends to their favourite restaurants and tries new dishes of the delicious but spicy Indonesian cuisines that she has come to love.

When the group leaves the restaurant, the traffic has eased and the exhaust subsided she chooses to slowly walk back home. She loves this time of the day, when everything calms down, the heat is not too bad, although still sweaty to walk, and she has time to process the day's experiences.

She chose to work in Indonesia, a relatively poor, but emerging country not mainly because she knows she can help but because she wanted to get a perspective to the Swedish health care and hospital environment, and she definitely has.

9.3.2. HOUSEWIFE FOR A DAY – SARA

Sara loves early mornings, when the city slowly wakes up and the morning business starts to blossom. She loves the fresh air and the sound from the neighbourhood's chickens that wake up early too. For Sara a lot of her daily activities are taking part in the mornings, almost before sunrise and when the temperature is still nice and comfortable. This is before the sun starts to heat and when things still can be easily done. She is often the first in her house of seven people to wake up, but the other are not sleeping in long either.

Sara is nearly 50 years old and housewife. She lives with her husband and three children in a large and new built house on Batam Island, Indonesia. Her husband works in Siberia, and is often away from home. Their boys, 18 and 20 years old, both live in the house, together with their wives. Sara has a third child, two years old Bella, that she and her husband adopted when she was newborn.

Sara loves to cook, and spends a few hours every morning cooking delicious Indonesian food. Some is made in the new indoor kitchen and some is cooked on the backyard to keep the smell and heat outside the house. She also likes to go the market herself, to make sure she gets the freshest products available. The best time to shop is in the early mornings, before it gets too warm. Other household chores, such as cleaning and washing, is shared with the two young wives, and it is done now and then during the day.

Bella often wakes up very warm, her pyjamas sweaty and one of the first morning chores for Sara is to wash. Sara says that the constant heat is much worse for the children than her, especially Bella that is too young to understand why she is not feeling well or drowsy. Sara often let Bella be undressed, or in only a thin t-shirt and her diaper, for the morning hours to cool down before the worst heat. In this heat, it is better to take a rest, slow down and relax and wait for the evening, according to Sara.

Sara mentions sweating as one of the worst problem with the heat and has many negative associations to it. If she is dressed up it is not very nice to be sweaty but in other situation no one should not care too much, Sara says. Tissues are good to use. Children have a harder time than adult in the heat and they sweat a lot in the face and scull. Another problem could be feeble, but for Sara it is not a big problem because she plans her day herself and takes it very easy during the midday.

Sara is not leaving the house during the day very often, or if she is, she is going to some friend's house. She also likes to be very calm during the hot hours of day, because there is not very much to do about the heat. She spends the time talking to friends and watching TV. Bella is not aloud to be outside very much either, because it will make her skin brown. When they are going for some daytrips, Sara has a cream made of rice flour that she always put on Bella, both in the face and on the arms to keep her white.

The weather is often mentioned by Sara to be hotter now than before, especially in the urban area. This is often said to be because of global warming, but she sometimes also says it is because of all the people, the motorbikes and the cars. Whatever the reason is, Sara is of the opinion that if it get any warmer the life will be very hard where they live, and in many other parts of Indonesia.

Sara does not drive herself, neither car nor motorbike. But she is lucky because the family has a car, and her oldest son drives it, when her husband is not around, for example to go to the supermarket once every second week or so. It is according to Sara a luxury to have a car, because then she does not have to be in the sun, and on the motorbike not as much food could be brought. But the motorbikes are the main transportation used in the family.

The part of Batam Island where the family house is located is very populous, and the house is close to each other and the roads small. The house is built in bricks and concrete, with two floors and has nearly no garden area. The kitchen is placed inside the house, and so is the toilet. The house has no air-conditioning, but high ceilings and many windows to open and balconies shade by roof in two directions.

She does not like air-conditioning but she sometimes use it in the car, and sometimes she likes to be in the supermarket for a while, but the house is not equipped with one.

When the sun goes down she starts to cook again, or heat some of the food from the morning, and a buffet with many dishes is served to the family every night. Often Sara, Bella and some guests eat first and then the boys eat when they come back home later after finishing their work or meetings with friends. If there is anything left, it is often given to the neighbours that are in need.



Sara does not cover her head, and feels ok to wear t-shirt, but always have long trousers. She is not sure why, but says it is just because she is very used to it, rather than religious rules. She has open shoes. She always dresses her daughter in thin dresses to help her not get too warm. Clothes is always changed before leaving the house to make sure they are fresh and not smelly, and they are changed as soon as coming back home to make sure not to bring the dust and dirt into the house.



9.3.3. TOUR GUIDE FOR A DAY - ADI

Today Adi has not got a tour booked and therefore has not put on an alarm. He still wakes up quite early, around seven. Days like this are always spent on a tourist spot, often the beach, where it is easier to find customers and get to know people that might need a driver in the future. It is tiring to look for new customers but it is good to have something to do when not having a booked job. By spending time on these places he also has a lot of friends there, that can recommend him to customers when he is not present.

Adi have a quite big circle of regular customers, that calls when they need a driver or tour guide, but he also have to find new customers to make sure he have enough work to earn money for living, and hopefully some saving for the future.

Adi origins from Sumatra, but lives and work on Bali since seven years. He works as a private driver and tour guide, for both locals and tourists. Adi lives in Jimbaran, south Bali, together with his younger brother and a friend. They all live in a shared apartment with four rooms. The apartment is very nice, with an inside toilet and a kitchen connected to the house but located in the garden. Jimbaran is a relatively calm area, quite close to the sea but between the tourist's favourite spots, which means that quite a few hours everyday the roads are crowded and it will take an hour to drive just a few kilometres. Adi often tries to avoid these worst hours of traffic jam, because it is hot and a lot of pollution in the air. It is also often quicker to use the motorbike these times, because then there are more roads to choose between and he can pass between the cars.

Adi has a simple uniform when working, suit trousers or jeans and shirt, normally open shoes, but it depends on the costumer and he also brings a jacket if the tour is to the mountainous areas where it is cold and often wet. He does not bring any extra shirt, but says that it quite often is very warm in the car and outside if he has to walk for a while so he sometimes wishes he did.

Adi does not own a car himself, so when he finds customer that want to have a tour he has to rent a car. He has a few places that he knows gives him good price, and also are located in places close to where the tour starts so he does not have to drive any extra miles. The car Adi rents always has air-conditioning but he only use it in crowded places when the win-

dows can't be opened. Some tourist also wants to use it, but not often his Indonesian customers.

Hurry and stress are not often seen in the Indonesian culture and not in Adi. But in the traffic he can be as stressed as everyone else, or stressed is not the right word according to himself, it is just that he won't move at all if he is not offensive. He likes to drive fast, with the wind is blowing. As soon as the car is parked for a while, it will be very hot to enter again, because it is almost impossible to find parking spots in the shadow. Most cars have black leather seats that burn in the back and bum when hot. He tries to go back to the car before the customer to have time to open the car and lower the temperature a bit. It is a service that his customers like.

Adi thinks people that are not used to the heat have a harder time to stand it, but also says that many do not know how to handle it. For example does he think many walk too fast and too far, which will be very tiring in the hot climate. Tourist has one advantage that he is a bit jealous to: tourist places have air-conditioning. For example shopping malls, ATMs and coffee places, where he is not always welcome, and cannot afford, and therefore he often has to wait outside in the heat also those hours, when his customers cool down. Often this is ok, because he does not like cool air very much, but after a long drive, he could have liked it for a while.

Adi eats breakfast, according to himself. Observations show that it consists of a cup of coffee, with milk and a lot of sugar. Lunch is only eaten days when he feels hungry, but dinner is the most important meal. Even if Bali offers a lot of international food, also with Indonesian styles, Adi always stick to the traditional food. He is from Sumatra, and if possible he choose a restaurant with Sumatran food, but otherwise he mostly eats food from from Jawa. The balinese food is not an option, because it contains pork. He drinks tea, often hot to meals but iced during hot days.

After dinner Adi spends some hours with friends, and then often go to bed quite early. When it is too warm to sleep in the bed, he says that a colder option is to sleep on the floor.





9.4. ETHNOGRAPHY : SUMMATION

9.4.1. NEED

A product that can be an adequate alternative to air-conditioning and evoke interest for the environment would be beneficial, due to the environmental problem that Indonesia have.

9.4.1.1. Hot situations

When a person gets warm, some parts of the body are warmer than other, and some circumstances makes the heat even worse. Torso, at both back and front, face and neck were often mentioned as hotter than the limbs. Circumstances making heat worse are sweating, body parts that touch each other or touch an other person and tight fitted thick clothing but also when the air movement is limited such as when seated or in a crowded place.

Three main groups of hot situations were found in the ethnographic research; work, everyday living and on the roads, which is more or less all the time for many people. Most often mentioned as hot were:

Work - *high intense, heavy loads, hot hours, hot buildings, in direct sun and lack of air movement*

Everyday living - *hot home or building, during and after daytime activity, household chore such as cooking, hot restaurants / serving spots and heat radiating products*

On the roads - *hot car, waiting for public transport, in public transport, slow traffic or stop at red light, bicycling and walking*

9.4.1.2. Requests on products

A product for personal cooling could be either worn, for example a vest, or not worn, for example placed on a chair, which means it will be more or less possible to use in active situations, such as when a person is moving around a lot.

The addition of an extra layer of 'clothing' does not seem to be a problem in Indonesia where most people is already covering.

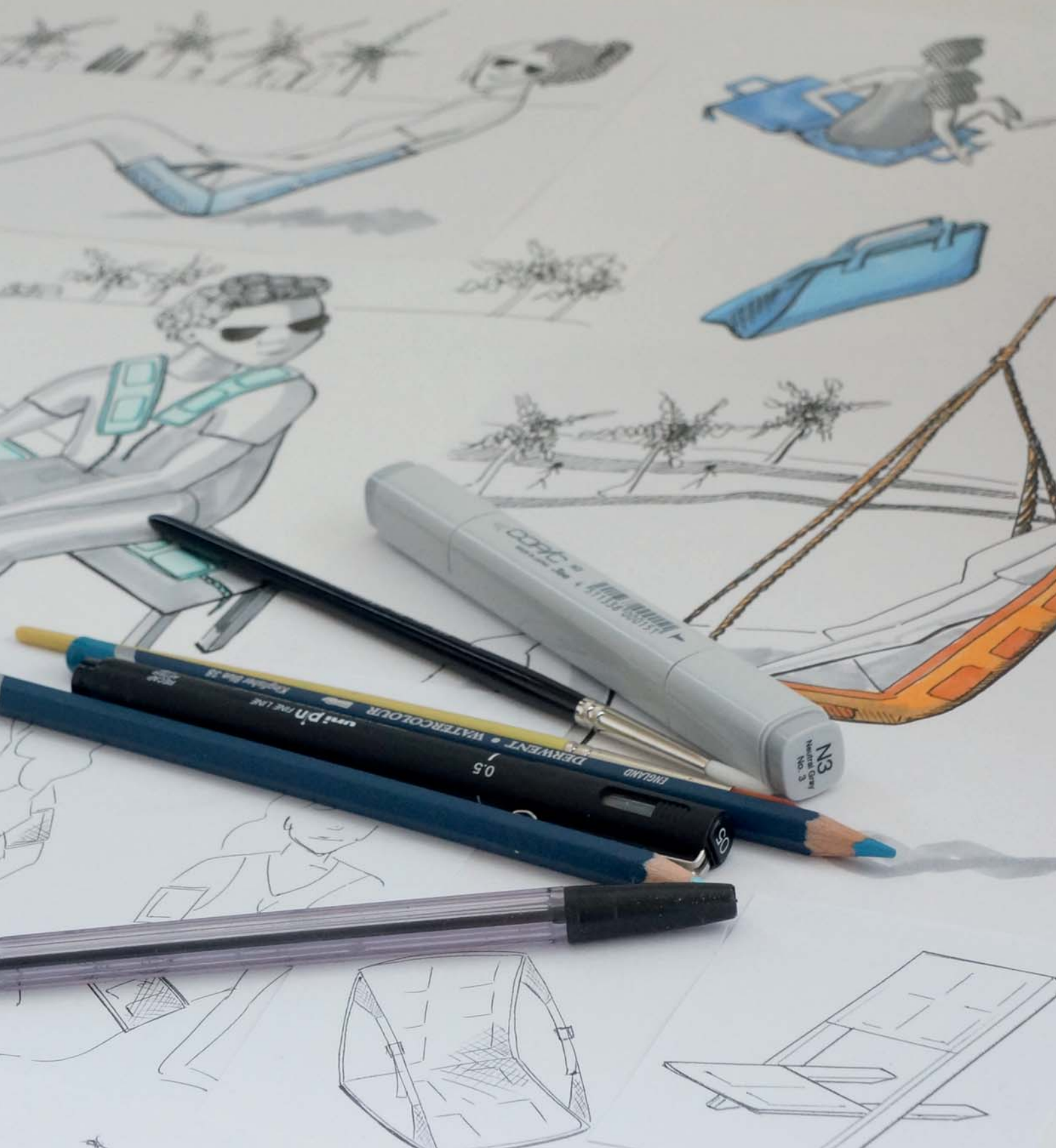
An active situation does not have a specific location and the person will often perform on high activity level. Core values for a product needed in this case is: easy to use, lightweight, cool, free movability, tight fit / second skin, comfortable.

A sedentary situation, as well as resting or recovery, on the other hand will often be at the same location, often in shade, which means that the product might not have to be carried around during work but are waiting at one spot for later use when most needed. Core values for a product needed in this situation is: comfortable, easy to use, calm and relaxing.

Despite what product that will be developed, there are some product qualities requested. A full list is presented in "APPENDIX VI" and a summary of the most important is outlined in Table 14.

Table 14: Requested product qualities

FEATURES (FUNCTION)	High cooling capacity combined with a low weight Possible to use in variety of hot situations; active and resting, outdoor and indoor Allow replacement of cooling element
FEATURES (DESIGN)	Adopted for the usage context Attract people in need of cooling
ERGONOMICS	High liberty of action and no restriction of body movement Suit many different sizes Easy to use
ECONOMY	Affordable Durable





PHASE 3 : DEVELOPMENT

10. IDEATION

This project started from the rectangular and solid Temptech element, through the finding and investigation of potential users and has now reached the phase of development of a cooling product, based on previous findings; needs and requests.

10.1. IDEATION : PROCESS

10.1.1. COOLING AREA

A figure showing the area where the elements can be placed and which body parts the participants in the study have pointed out to be the hottest was sketched. The figure is a simple visualisation of facts found in the pre-study and ethnography. This figure will assist the ideation to make sure the ideas are beneficial for both the users comfort and the elements cooling capacity.

10.1.2. IDEATION

The actual ideation process begun with an organisation of ideas that have emerged earlier in the process and proceeded with a few ideations sessions, mainly brainstorming and sketching, and later continued with model building workshops. The initial idea was to involve a group of Indonesians in the ideation process, in a workshop session, but due to lack of workshop material, this was not feasible, and therefore the researcher mainly carried out the ideation.

Brainstorming, of ordinary and less ordinary type, was mainly used for idea generation. Brainstorming can be endlessly varied, for example words and images are used to broaden the mind and get a wide spread of ideas in this project. The sessions of brainstorming, often carried out by the researcher, but a few times together with Adi, were organised on different subjects, with a specific situation or a specific person in mind. For example, were 'active life' and 'resting period' given one session each.

Sketching was used, mainly as a tool to visually present ideas from brainstorming. Workshops where models were built, on the other hand, were very good for idea generations. In the beginning thumbnail models were built by paper, fabric, tape and thread. Later full-scale models were built for testing. These models were at the start 'quick-and-dirty', built by

simple sewing, lots of tape and other things found at home; belts, braces and mixed scrap.

The ideas from the ideation phase were sorted and the best ones were briefly analysed, which resulted in three main categories of products; active, recovery and simple. Active became the name of ideas that were possible and advantageous to use in an physically active situations, the title Recovery unified ideas that could not be worn, but could be used in a resting period or before /after the active situation. The third category, Simple, evolved from a mix of products, with the main vision that little cooling is better than no cooling, and unified simple product with potential low price. Ideas that were taken away at this step was those found to not reach the broad group of users addressed, such as backpacks with cooling in the connection area between bag and back and stationary cooling furniture.

10.1.3. EVALUATION

The chosen ideas were presented as sketches, which are expedient in print and for a quick review.

Models were very useful in evaluation phase, for a truthful feeling and to find out the true potential of the ideas. The knowledge gained from trying and wearing these models were used in all steps of evaluation. Not all models could be built, but most could be experienced in a more or less realistic representation.

10.1.3.1. Pros and Cons

The evaluation started to bring up pros and cons for each group and thereafter the ideas themselves were evaluated in the same way. Thoughts, for and against each idea, were printed together with the sketch and in this report the most influential thought were sorted and presented together with the sketch.

The pros and cons were mainly thought from the researcher but were also requested from other people, for example the international aid workers interviewed in the end of the ethnographic research.

10.1.3.2. Eliminations chart

The ideas were put on the top line of a matrix and criteria derived from the ethnographic study and literature review were put in the first column. Criteria used were organised in three groups, ordered by weight from most important to fulfil, the top three criteria, to the less, but not without great value, bottom three criteria.

Criteria used in the elimination chart:

- Cooling capacity
- Weight
- Affordable
- Use in activity
- Use in recovery
- Sweat evaporation
- Easy to use
- Easy to wash

These criteria were by the researcher given grades; plus, zero or minus (+, 0, -). A + meaning the criteria was fulfilled and a - was used if not. The ideas were assessed in respect to the other ideas fulfilment of respective criteria. Zero was used for ideas that did fulfil a criterion, but not in the most preferred way. Both the total score of the groups and the score of the single ideas were summarised.

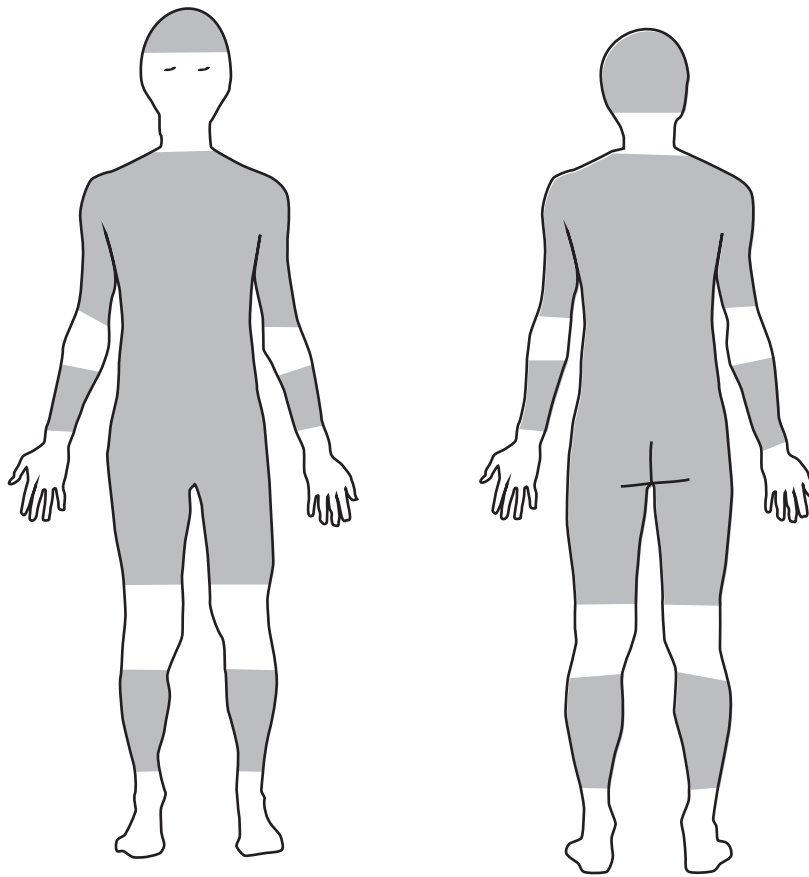


Figure 14: Area where Temptech elements previously have been used for cooling

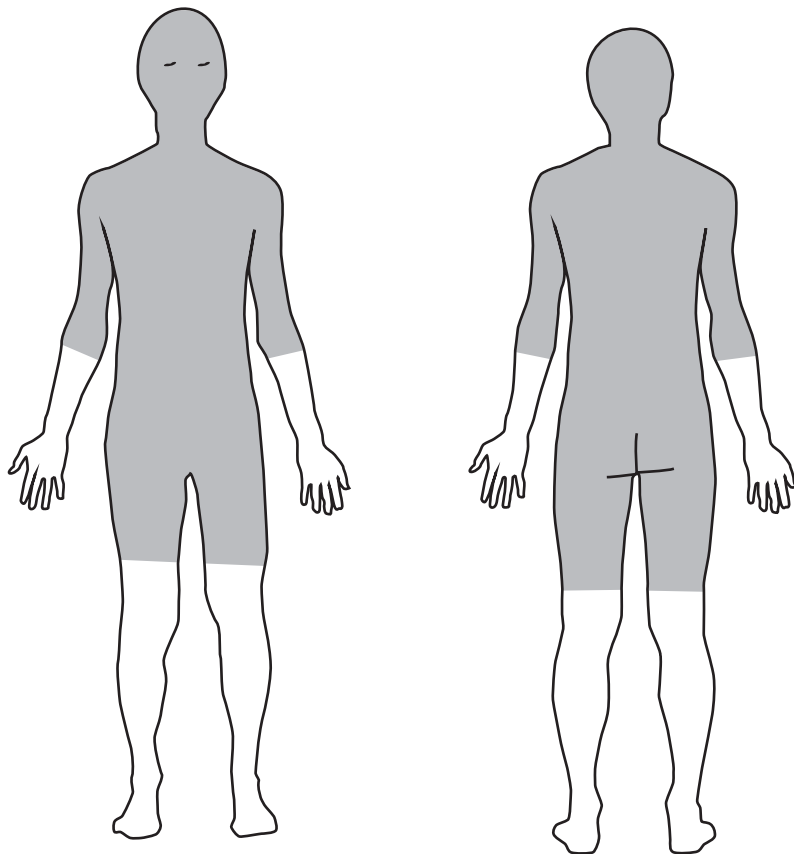


Figure 15: Hot part of the body found in the ethnographic study

10.2. IDEATION : FINDINGS

10.2.1. COOLING AREA

Skin areas that can be comfortably covered by Temptech element are shaded in grey in Figure 14 and the areas that were found in the ethnography to be the hottest part of the body are shaded in Figure 15.

10.2.2. IDEAS

This chapter presents a selection of ideas from the ideation process.

10.2.2.1. Active situation

A product for active situations needs to be light, comfortable, tight fitted, and it should not limit the user's movement. It is a plus if it can be comfortable used in other situations too.

Active idea 1 : Necklace (Figure 16)

Active idea 1 is a cooling necklace consisting of about 6-7 cooling elements, cooling both back and front of the upper body and that can be advantageously combined with Active ideas 2. A simple belt that connects the lower part of the back and front has to be added to give the design a better fit and better cooling possibilities.

Active idea 2 : Waist belt (Figure 17)

Active idea 2 is a stretchy waist belt with about 8 cooling element. To give a larger cooling area it is combined with stretchy arm belts, with one or two elements. The idea has a simple opening in front.

Active idea 3 : Back cooling (Figure 18)

Active idea 3 is a cooling product inspired by ski back protection. It consists of about 10-14 cooling elements of which eight are placed in the back and four on a waist belt. Two simple straps hold the back in its correct position and can be adapted in lengths.

10.2.2.2. Pros and cons : Active

All ideas together with lists of their pros and cons are found in "APPENDIX VII" while a summary of the most important pros and cons is presented below.

Active idea 1 is found to be simple and lightweight, which are the pros. The cons are that the idea has low cooling capacity, small cooling area and will be too loosely fitted to actually cool very well.

Active idea 2 is found to be simple but still cools the warmest part. Other pros are the tight fit that should have no interference with any movements and the possibility to adjust the cooling area slightly by

oneself. A found con was the lack of cooling on the upper back and chest.

Active idea 3 has the best cooling area of these three ideas combined with tight fit and no interference of movements. It is slightly more complicated than the other ideas, and needs to be fitted to the user to a higher degree.

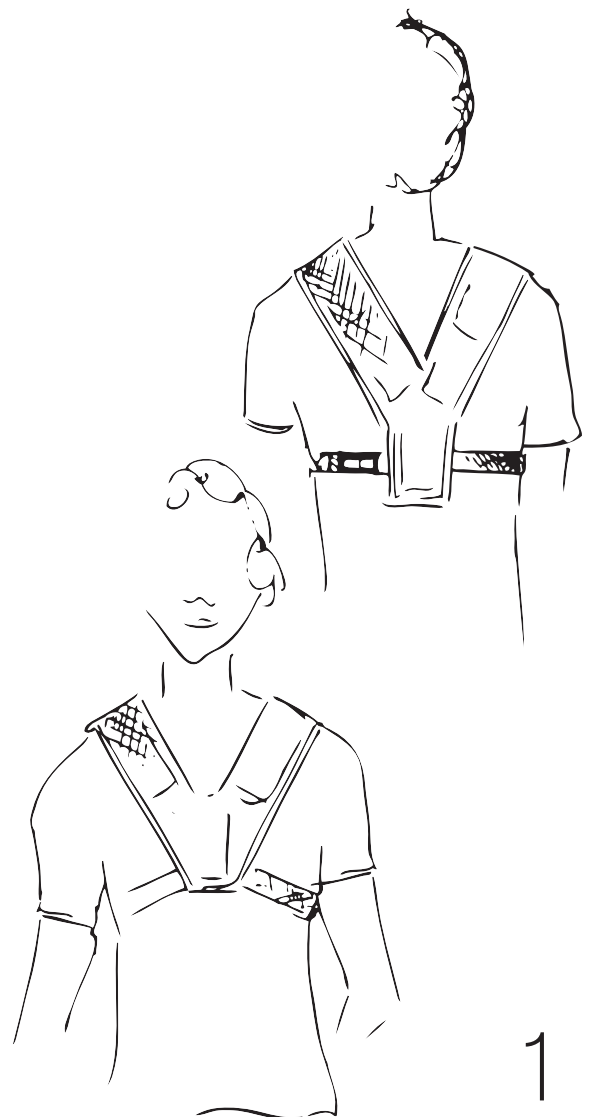
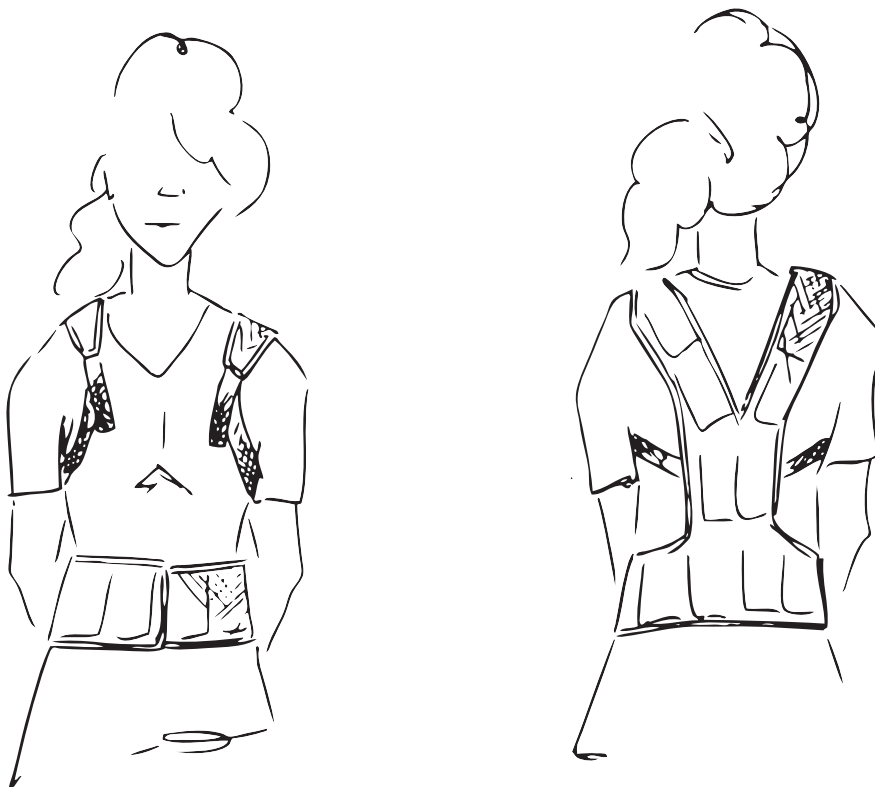


Figure 16: Active idea 1



2

Figure 17: Activa idea 2



3

Figure 18: Activa idea 3

10.2.2.3. Recovery ideas

Ideas for recovery, resting or sedentary work, need to be comfortable and simple to use. A product suitable for these situations can often be placed on one spot, where the user comes back for rest or is always working, and is therefore not requested to be as lightweight as worn products are.

Recovery idea 1 : Sit mat chair (Figure 19)

Recovery idea 1 is a simple, ground placed sit mat chair for resting, which comes with 8-12 cooling elements. An alternative is that it hangs in a tree. This idea cools the back of the body.

Recovery idea 2 : Hammock (Figure 20)

Recovery idea 2 is a cooling hammock with 8-12 cooling elements. This is a product to be used for relaxing and recovery. It needs to be attached to two fixed points.

Recovery idea 3 : Beach chair (Figure 21)

Recovery idea 3 is a cooling chair of beach model with 8-12 cooling elements. It has a simple steel frame and can be folded to flat.

10.2.2.4. Pros and cons : Recovery

Recovery idea 1 has a large cooling area and is possible to use in many environments. The cons are that only the back is cooled, that the user has to be seated to use it and also has to bring it to the place where the resting will take part. It also adds some strain on the material that the sit mat chair has to be placed on the ground.

Recovery idea 2 has a large cooling area that encloses the body while putting one's weight in the hammock. Cons are the need of suspension and the large covered skin area that will hinder sweat from evaporating. If the product will be left outside, the elements need to be taken out and stored / charged in a colder place which can add extra work.

Recovery idea 3 is a comfortable seat that cools a relatively large body area. It will be a disadvantage that it is heavier than the others. If the elements are stored in the chair it has to be fitted into a cold storage place, which can be a problem in Indonesia. Another option is to remove the elements until needed.

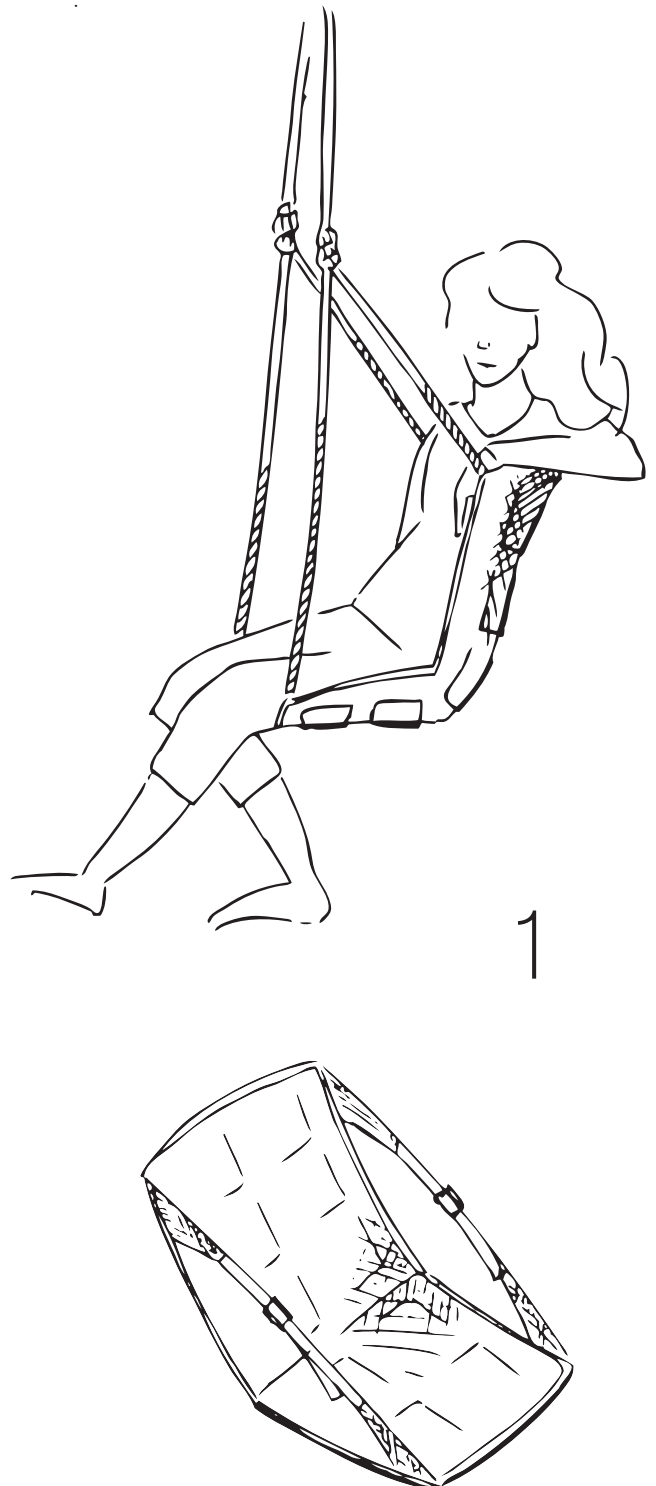


Figure 19: Recovery idea 1

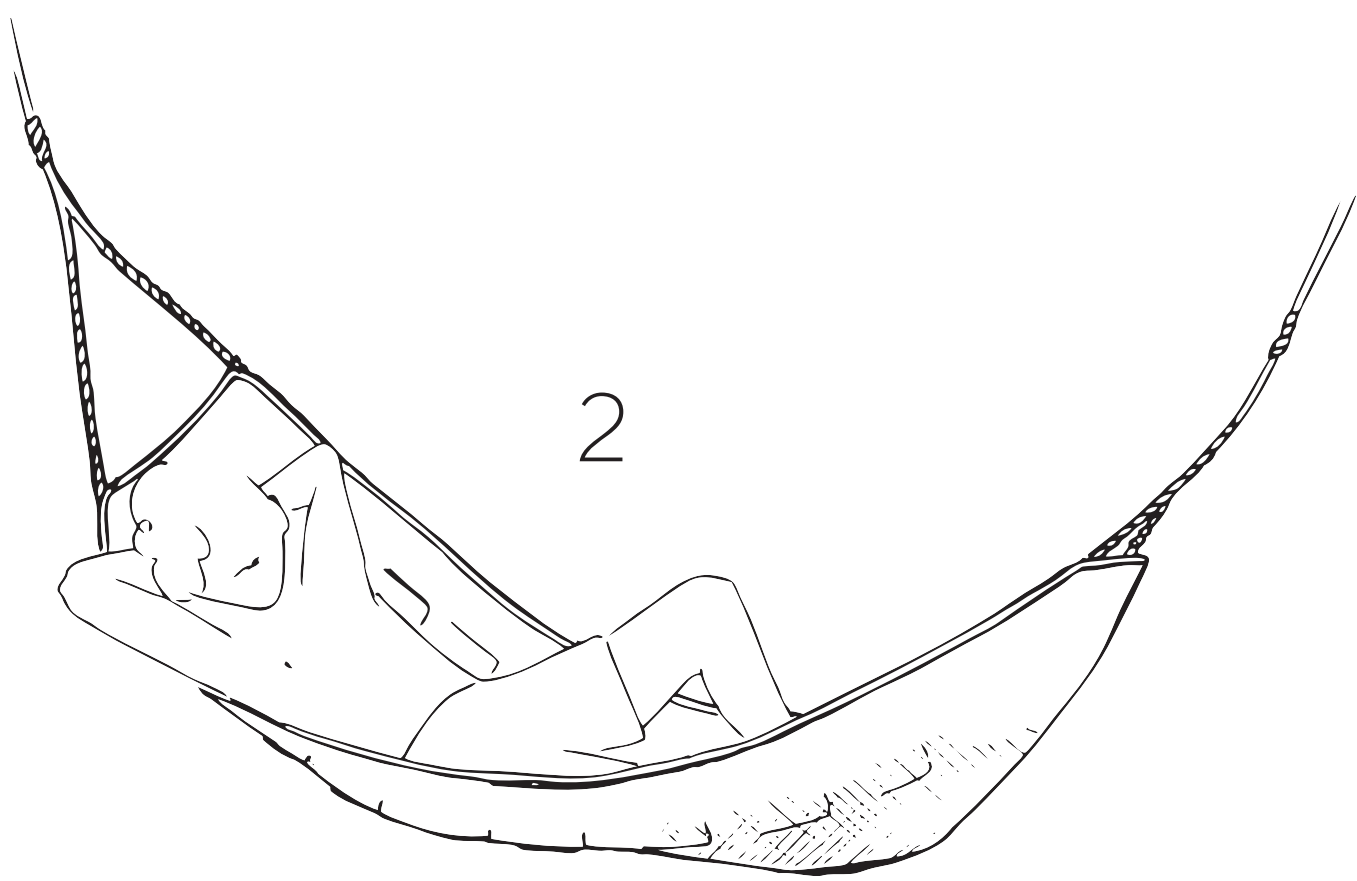


Figure 20: Recovery idea 2

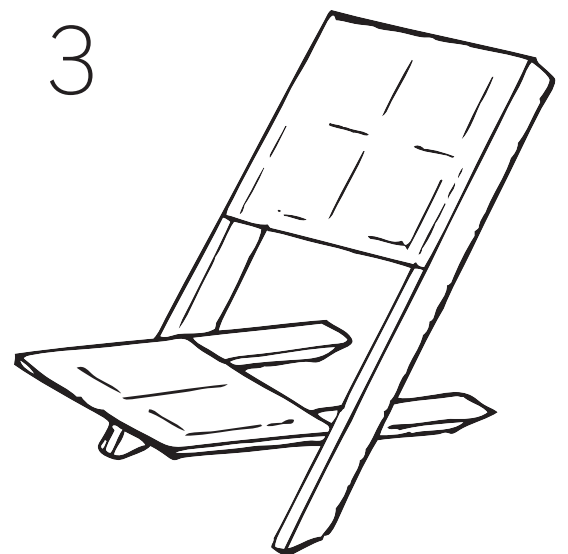
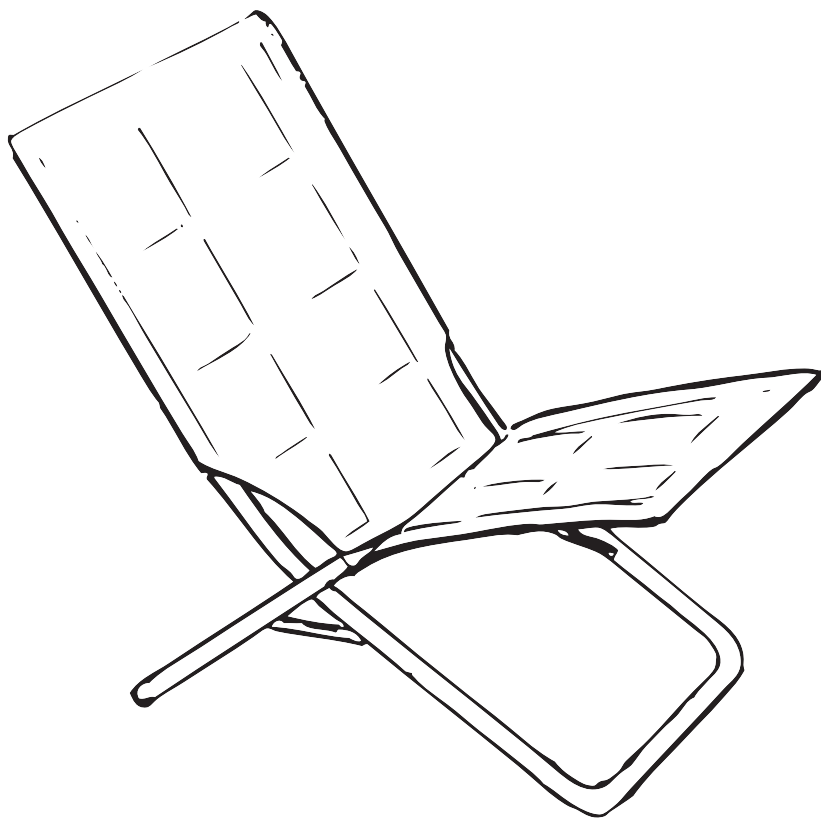


Figure 21: Recovery idea 3

10.2.2.5. Simple ideas

Ideas in this group have not been driven by a specific situation but with aspects of affordability and that some cooling is better than no cooling, regardless how few element that can be afforded.

Simple idea 1 : Tie belt (Figure 22)

Simple idea 1 is cooling elements lined up on a row. This idea can be used in various ways; to sit on, to hang around the neck or to tie around the waist, to mention a few.

Simple idea 2 : Sit mat (Figure 23)

Simple idea 2 is a foldable sit mat containing for example 4 or 9 cooling elements. It will cool the lower back, but could be combined with for example the arm cooling in Active idea 2.

Simple idea 3 : Sections (Figure 24)

Simple idea 3 is a seat cover cooling in separate parts, consisting of a pocket for the cooling element and a strap for it to be placed on. It can be used on various items, such as chairs and seats.

10.2.2.6. Pros and cons : Simple

Simple idea 1 is flexible and simple to bring / use. Other pros are that it has low weight and could be relatively cheap. Cons are that the cooling area is small and the elements are few.

Simple idea 2 is a simple idea that could be of any size, for sitting or lying, and be put on different places, such as on the ground or on a hot seat. Its cons are that it has small cooling area.

Simple idea 3 has a large cooling area and is customisable, but too many loose parts may be a problem or lost.

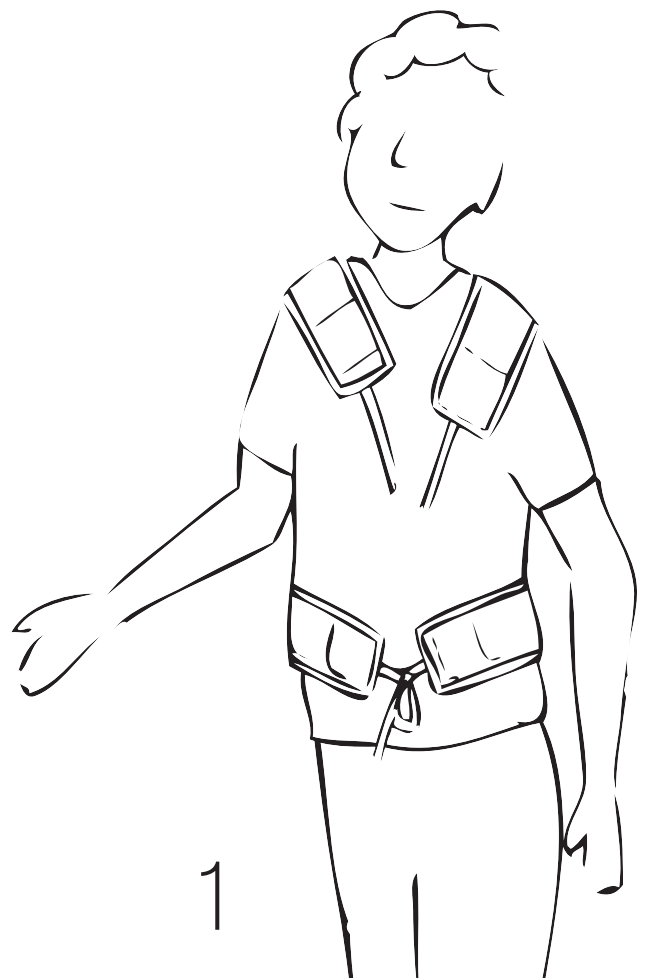


Figure 22: Simple idea 1

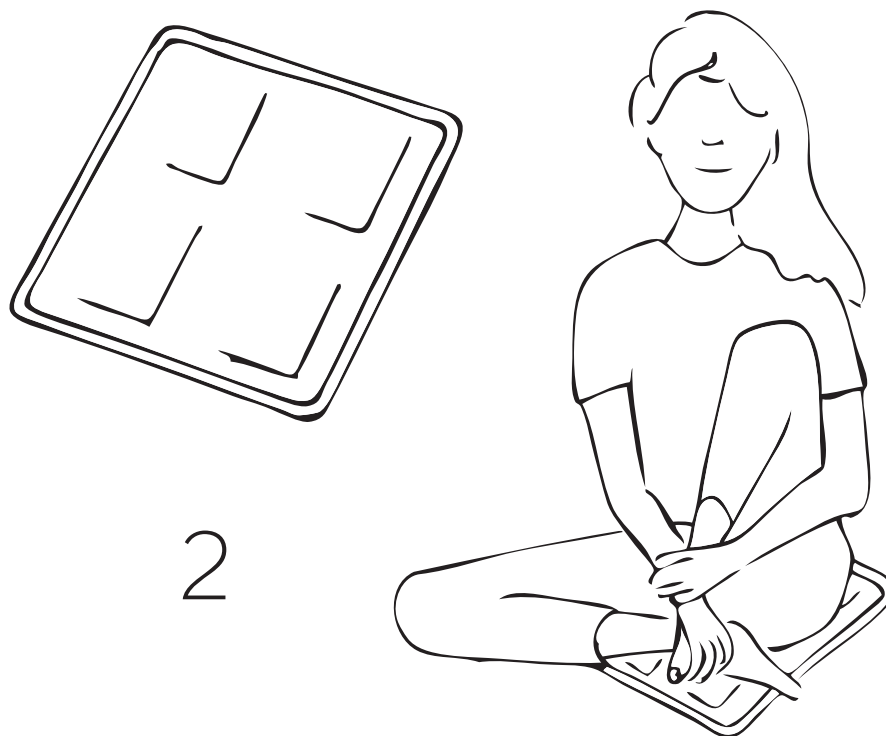


Figure 23: Simple idea 2

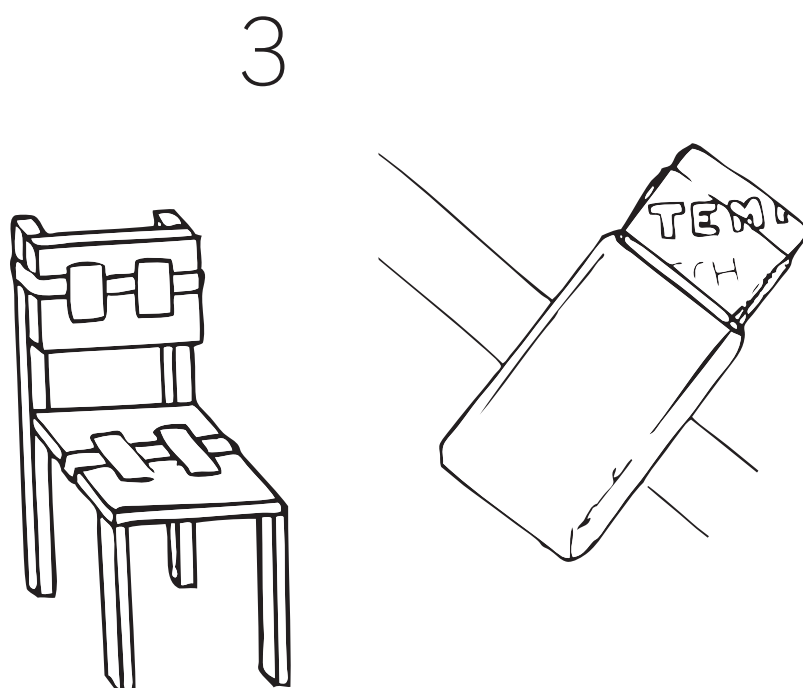


Figure 24: Simple idea 3

10.2.3. ELIMINATIONS CHART

Two ideas got full score on the most important criteria; cooling capacity, weight and affordability, as seen in Figure 25. These are Active idea 2 and Recovery idea 1, of which the first has better overall score and has a wider range of situation in which it could be used.

All ideas from the group simple score acceptable in total, but cooling capacity is crucial for a cooling product. This only Simple idea 3 is found to have, but due to that this product limits to be used in active life, it is not found to be competing with the product that scored highest; Active idea 2 and 3.

Active idea 2 gets the total high score, closely followed by the Active idea 3. The only difference is weight, which at this step is not fully defined. Active idea 3 is one complete product that could only be used in one way, whereas the other idea is simpler consists of a few parts and can be varied to a higher degree. Where Active idea 3 has a better cooling area, Active idea 2 is believed to be able to be combined with additional back cooling.

ELIMINATION CHART










	ACTIVE			RECOVERY			SIMPLE		
	1	2	3	1	2	3	1	2	3
									
cooling capacity	-	+	+	+	+	+	-	-	+
weight	+	+	0	+	0	-	+	+	0
affordability	0	+	+	+	0	-	+	+	+
use in activeity	0	+	+	-	-	-	-	-	-
use for recovery	0	+	+	+	+	+	+	+	+
sweat evaporationv (at least two hot parts)	+	0	0	-	-	-	+	+	0
easy to use	+	+	+	0	-	0	+	+	0
easy to wash	0	0	0	0	0	-	0	0	0
	2	6	5	2	-2	-3	3	3	2
		13			-3			9	

Figure 25: Elimination chart

10.3. IDEA CHOSEN FOR FURTHER DEVELOPMENT

Active idea 2 (Figure 26) is chosen to be the idea with highest potential to become a requested cooling product on an emerging market in tropical climate and that also has greater potential on other markets and in other situations too.

The cooling capacity and affordability are highly valued, which means materials, features and design will all be kept relatively simple.

The idea is at this stage thought of as a waist belt, but in sections that can be combined in various ways. Other areas that will be developed are, for example, ergonomics, fitting, material and expression.



Figure 26: Waist belt idea chosen for further development

11. CONCEPT DEVELOPMENT

11.1. CONCEPT DEVELOPMENT : PROCESS

11.1.1. MATERIAL

Materials, both basic and very advanced, have been deeply investigated and developed by TST Sweden for many years and the material for this product will therefore be chosen upon advice given by them. This will also ensure materials beneficial in their production are chosen.

11.1.2. AESTHETICS AND EXPRESSION

The aesthetics and expression of the product are sought in the findings and insights from pre-study and ethnography. Many contradictions, such as heavy elements and a lightweight product, light colour for cool feeling and dark for durability, durable but airy, are found and have to be considered.

11.1.3. PHYSICAL ERGONOMICS

11.1.3.1. Anthropometrics

The need of exact measurement is neglected by the design, because it should be possible to adapt from very small to as large as needed, but as guidance for the development of the product anthropometric data is beneficial to have.

Anthropometric data of interest are the circumferences of waist, arms (upper and lower) and legs (upper and lower) for adult Indonesians, which have not been found, at least not in any reliable reference. Measurements for Chinese men and women, as well as European and American are found. The Chinese values are chosen to be closest to the sought ones. Measurement for waist circumferences of Indonesian clothes sizes are found and used as guidance.

11.1.3.2. Comfort

Models will be used to test the comfort of the product during the development process, but also be based on the findings from the ethnographic research and the researchers own experience of similar products.

The first part is to understand how the Temptech element is most comfortably placed on the body and at the same time absorbs as much heat as possible.

11.1.4. MORPHOLOGY CHART

The chosen concept was further developed, part by part, assisted by a morphologic chart. Parts to be looked deeper into were put on the vertical axis of the morphologic chart and the possible partial solutions interesting for further investigation were placed on the horizontal axis. These ideas are described in words in the report but were sewn and tested in the process.

Parts to be further developed by this method:

- Module size
- Pocket design
- Connection mechanism
- Connection design

11.1.5. EVALUATION OF PARTIAL SOLUTIONS

For test and evaluation, all the ideas in the morphologic chart were sewn as quick and simple models. These models were given to seven people for testing and evaluation. Comments from the test participants were noted and combined with the research result from the ethnography.

The final assembly, to be combined from the partial solutions, were kept in mind when the most beneficial combination was selected, as well as the usage situations and user of the final product. Of the tested solutions, both the test group and the researcher often preferred the same idea.



11.2. CONCEPT DEVELOPMENT : FINDINGS

11.2.1. MATERIAL

The chosen material should assist the comfort and the performance of the final product, such as make sure that the Temptech elements can be nicely fitted on the body and cool as much and as long as possible. The material should be affordable and durable.

11.2.1.1. Natural fibres

Natural fibres are made from plant or animal sources. These fibres are degradable and therefore it is often preferred in an environmentally friendly product. A negative aspect is that it often requires quite a lot of both water and chemicals to produce natural fibres, especially cotton. Another negative aspect is that the durability is not always as good as for non-natural fibres, for example do washing and usage wear it down.

11.2.1.2. Polyester

Polyester is a durable synthetic fibre produced of crude oil, but it can also be made from plant fibres. Polyester is the most commonly used synthetic fibre today. Polyester can be soft or hard, functional or ordinary, covering or mesh.

109 megajoules are needed to produce one kilogram of polyester, compared to cotton that only requires 50 megajoule, but polyester can be recycled without loss of any material quality and do not require the same amount of water and chemicals as cotton. (Åsnes et al 1997)

11.2.1.3. Chosen Material

A natural fibre, environmentally friendly and locally produced, would be the most sustainable option to use in this product. But as a test of the durability of such fibres cannot be fitted to the timeframes of this project, the advice from TST Sweden to use polyester, as they do today, will be listened upon.

Figure 27: Material to be used in the final concept. From top: polyester mesh, elastic edging, polyester functional fabric (front and back). Also to be used is Velcro.

11.2.2. AESTHETICS AND EXPRESSION

The product should have an attractive appearance that reflects the values, which mainly are affordability and environmentally friendliness. These aspects should both be seen in the overall design, material and colour chosen.

The main expression sought in the design of the product is seen in the expression board (Figure 27). The core words expressed on the board are cool, comfort and light, which is what the final product should strive to express.

Figure 28: Expression board – Cool, comfort and light



11.2.3. PHYSICAL ERGONOMICS

11.2.3.1. Anthropometrics

Anthropometric measurements from Indonesia could not be found. This is not a problem because the design has more or less eliminated the need of exact measurements. Other measurements, to be used as guidance, are found. For example Chinese waist anthropometrics and Indonesian clothes sizes, which are presented in Table 15.

11.2.3.2. Comfort

A charged Temptech element, ready to absorb heat and cool the body, will always be solid. Therefore it can be more comfortably placed on soft parts of the body. It will be less comfortable if placed on a protruding bone, such as the spine, especially when movements, such as bandings are required, or the user will sit on a hard chair. The elements could easily be fitted comfortably around the waist and there is no problem with the comfort when element is placed around the chest, on the ribs, as in the Cooling vest or on the backrest of a chair.

The Temptech element cannot be bent to follow a small curve and have to be placed on slightly larger and flatter body areas. The shape is rectangular which means an element can be placed in two directions, either standing or laying.

As the waist, arms and legs are more curved in the circumference direction, a standing element will be most comfortable to wear. The height of the element is small enough to not hinder bending movements if placed smartly, such as in the middle of the upper arm rather than on the elbow.

A tight fit is necessary to make best use of the cooling capacity. A tight but slightly stretchy belt will be more comfortable to wear. Sweating is a problem when tight fitted clothing is worn, and despite the Temptech element lowering the amount of sweat, both where it is placed and the overall, it does hinder sweat evaporating as well. Therefore a smart chose of material can be beneficial, as well as a design that makes it easy to wash the fabric.

Table 15: Circumferences adults (centimetres)

	WOMEN	MEN
MEAN WAIST CIRCUMFERENCE (CHINA)	70	75
WAISTS CIRCUMFERENCE IN CLOTHES (INDONESIAN SMALL SIZE)	61	64
FOREARM CIRCUMFERENCE	18 and above	
UPPER ARM CIRCUMFERENCE	25 and above	
CALF CIRCUMFERENCE	34 and above	
THIGH CIRCUMFERENCE	40 and above	

(Bridger 2009 and House of legging 2012)

11.2.4. MORPHOLOGIC CHART

Partial solutions for four specific parts of the section are combined into the morphological chart (Table 16). Other ideas were suggested but early results show these ideas to not be beneficial in this specific product and are therefore not included in the chart.

A belt can be an assembly of one or more sections, where a higher number of sections gives greater variations in size, due to that every added section adds a new connection area where length adjustment is possible. A smaller section will be better adapted for cooling of other parts than the waist, than one that is longer than the arm and leg circumferences.

Every section can contain one or more cooling elements, where a higher number will provide more cooling on a smaller area, when no lengths are lost for edging. The number of elements in each section depends on a few different parameters; the part of the body it will be used for, circumferences of these parts, joining design, how many sections that

will be joined to the belt, preferred element placement. Important things to consider are the cooling capacity, the weight and the total price, where any added Temptech element will add cooling capacity and weight but also a cost much higher than for any added fabric. It is also possible to make a long belt with many pockets and let the customer decide how many pockets to be filled with Temptech element, but any empty pocket will add unnecessary covering of the body.

The cooling element could be kept in place in a few different ways. The pocket design has to make sure that the cooling elements are placed as close to the skin as possible and that no element is lost by accident.

The joining of two elements could be designed in a few different ways, from very simple to more advanced connection mechanisms.

Table 16: Morphologic chart

SECTION SIZE	1 element	2 element	3 element	4 element	full belt
POCKET DESIGN	open pocket	pillow case	zip	button(ed)	velcro
CONNECTION MECHANISM	velcro	buttons	buckles	zip	tied knot
CONNECTION DESIGN	full overlap	one strap	two straps	curved	
MAIN SHAPE	square	rounded	small as possible		

11.2.5. EVALUATION OF PARTIAL SOLUTIONS

11.2.5.1. Section size

The smallest section, with a single Temptech element, is possible to be combined to any length above its own smallest size, due to that two single element sections will in its shortest lengths be similar to the length of the longest that the single section can be adjusted to itself. This makes it useful for not only waist but also arms and legs. A single element section will always be the cheapest one to buy, but only one section will not cool the body very much. A belt of single sections will need about eight sections to form a waist belt. That is eight openings that might not be very useful but adds extra material, weight and thickness to the product. The belt with many connections will more easily start to twist itself, as the connection part is weaker and thinner than the pocket area. This can be frustrating when the waist belt is put on, but not a huge problem because the belt is easily made flat by stretching it slightly.

The test participants positively commented upon this section, but also some thought that a belt of full length would contain too many individual parts.

The next size, with two Temptech elements, can fit more cooling capacity on a smaller covered area, than the single element section. For a medium sized user there will be a need of four of these sections to form a belt, which means there will be four connections and about 20 centimetres of adjustment from smallest to largest size. A section with two elements, at least the test version, is possible to use for cooling of arms and legs, but not always as comfortable as combinations of single sections.

When more or fewer, than four, sections are considered there might be a uneven placement of the elements on back and front that could be both beneficial and a disadvantage. Some of the test participants made the point that an element placed on the spine will be uncomfortable, at least when bending the back or seated in a chair. On the other hand, can a smart placement and adjustment of the sections locate more cooling either back or front, if requested.

An eight element full belt would be nice and simple to use, but would not be more than a few centimetres adjustable and would therefore have to be done in various sizes to fit all users. It could be sold with empty pockets to lower the price but that would as

pointed out before cover an unnecessary larger area of the body until the customer has been able to fill all the pockets.

The test participants like the feeling of only having one belt and point out that a belt assembled from a number of sections should look and feel like one entity when being used.

11.2.5.2. Pocket design

A safe pocket is needed to make sure no element is lost, neither in use nor in storage. The test participants agree that zip, button or Velcro closure would make the insertion and removal of the element a bit too complicated and also add some cost. The test participants suggest a simple pocket with a pillowcase inspired closure or a simple open pocket with tighter top as the best solutions. It is also pointed out that the belt is tight enough to keep the elements in place in use and that a cooling bag for storage would minimise the risk of losing elements at other times. That means that the need for closure could be neglected, which facilitates the washing, according to the test participants.

11.2.5.3. Connection mechanism

A tied knot would be very simple and does not require any additional material, but is seen as relatively 'cheap' and hard to adjust. Zip and buttons is once again agreed to be too complicated and not very simple to be adjusted, if at all. This leaves the traditionally most commonly used Velcro and in other applications very trusted buckles as the favourites.

Buckles could be a bit complicated to open and close but is very easy to adjust and feels very secure. It adds an extra material, plastic or metal part to the sections but is possible to find relatively cheaply. The one tested is complicated to fully open which results in the test participants putting on and taking off the belt as a climbing harness; all parts already loosely assembled, puts it in place and ties it up.

Velcro is very simple to use but all test participants have experienced both good and bad use of Velcro, and therefore challenge this connection mechanism

more than the others. Velcro can be very annoying if it gets stuck on the wrong places and could destroy other materials quite easily. The test participants point out that the hard side should be placed where it will never touch the skin or clothes worn underneath the for example a cooling belt. The hard side should also never be left uncovered because it will then injure, for example, the arms (if a belt is used) or dirt from the environment will be stuck there. The soft side has no trouble and can be placed on any side and in any size. Velcro has the advantage of being cheap, durable and very simple to adjust; open and close.

11.2.5.4. Connection design

With a demand on the sections to be adjustable in lengths, either overlapping or separation has to be a part of the product. A full overlap would make it possible to by mistake cover elements with each other, which would be clumsy but could also waste extra cooling to the surrounding air. A smaller strap on one side of the element would not hinder overlap-

ping of the element but at least not invite as much as a full overlap. Two straps could, if one was put on each side make it impossible to overlap the elements but would also make the opening and closing more complicated.

The test participants think that one strap placed on one side of the section and connected with the other side of itself or another section would be the most simple to use. A simple strap with Velcro, such as on the wristlet of a jacket, is simple to use in the belt but needs a bit of practising to be tighten up when used on a arm. The test participants point out that a longer strap that is folded doubles, as an iPod case for running, is easier to tighten up. These do on the other hand require a lot longer strap to give the same lengths of adjustment. Also the buckles are easier to tighten with one hand.

Partial solutions to be chosen evolved from testing and are shown in black in Table 17 with the proposed partial solutions in black.

Table 17: Morphological chart with the proposed partial solutions in black

SECTION SIZE	1 element	2 element	3 element	4 element	full belt
POCKET DESIGN	open pocket	pillow case	zip	button(ed)	velcro
CONNECTION MECHANISM	velcro	buttons	buckles	zip	tied knot
CONNECTION DESIGN	full overlap	one strap	two straps	curved	
MAIN SHAPE	square	rounded	small as possible		





12. FINAL CONCEPT

12.1. FINAL CONCEPT : PROCESS

The final concept was sewn on a normal sewing machine for home use and with material from retail stores in Gothenburg. The aim was to produce the product in a way as close to what could be done in a professional manufacturing situation at one of TST Sweden's production collaborators.

The final module is made in three steps: assembly of the main covering material, adding Velcro and last the edging. Thereafter the Temptech can be added and the first product, a wrist cooler, is completed. More sections were produced in the same way, and as the fourth was completed the main product, the waist belt, was born.

12.2. FINAL CONCEPT : DESCRIPTION OF SECTIONS

12.2.1. OVERALL DESIGN

The sections will come in one size, which is containing two Temptech elements (Figure 29).

This section can be used alone as a cooling product or assembled, of two or more sections to a variety of cooling products. The concept products are further presented in next chapter.

The pockets to put the Temptech element in are designed with the simple locking mechanism seen in normal pillowcases. This makes it simple to put in and take out the elements, for example when time to wash the fabric. The pockets are design to make sure only one layer of fabric is in between the Temptech element and the user. Therefore the overlapping area is on the outside, away from the body.

A eight centimetre strap, with Velcro connection mechanism, on the left side of the section makes the strap fit together with the second part of Velcro on the other side, either with oneself or each other. A three times three sized male Velcro (hard side) is put on the inside of the strap and a four times eight sized female Velcro (soft) is put on the outside main area, on top of the element pocket. The hard side of the Velcro is the smaller to hinder that it fastens on any other part than it is meant for.

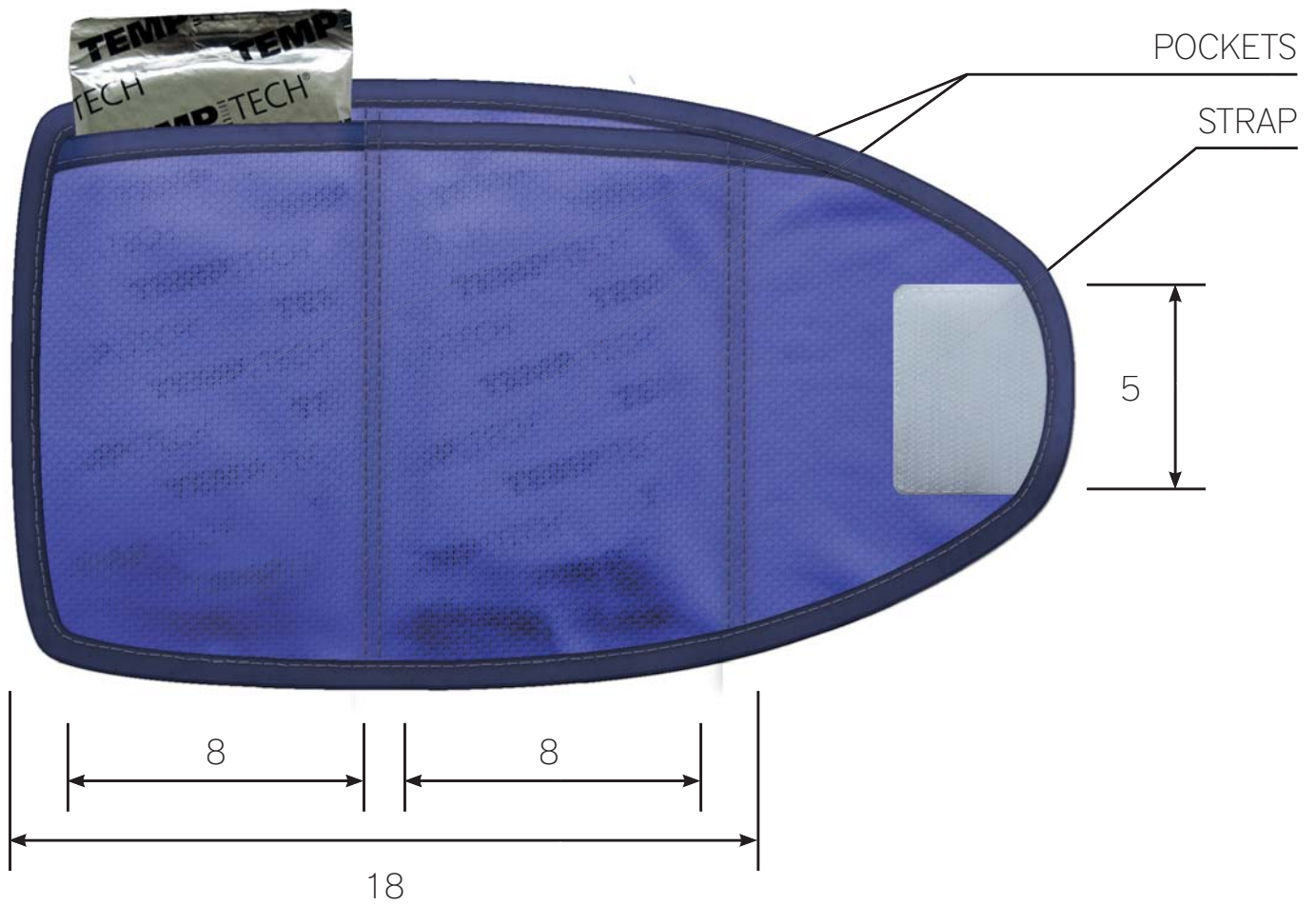
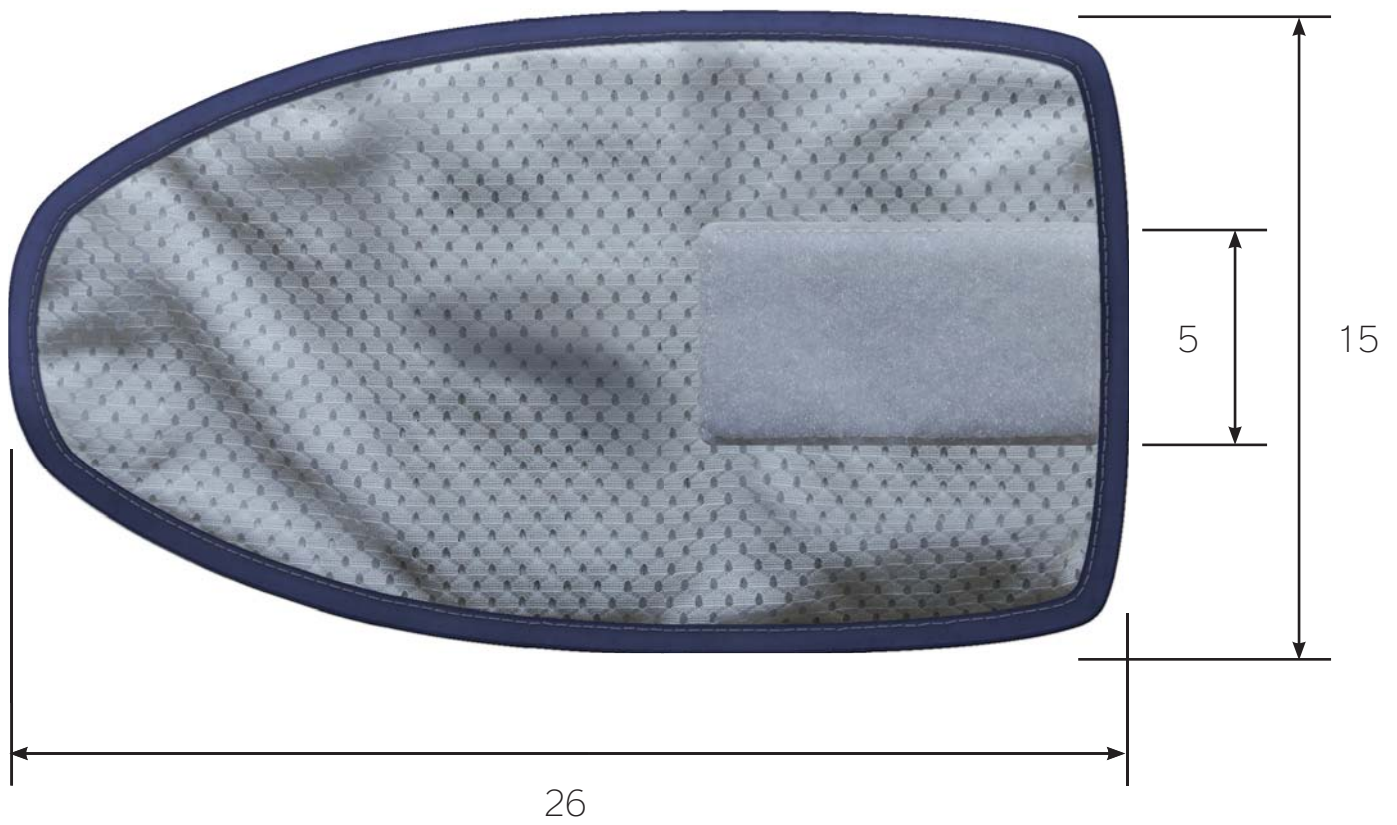


Figure 29: Measurements of outside (top) and inside (bottom) of the cooling section

12.2.2. MATERIAL (FIGURE 30)

12.2.2.1. Inside

A soft, lightweight, stretchy and breathable fabric is chosen as the inside of the section for best comfort (Figure 31, bottom). It is a functional polyester material with large evaporating area and made for high performance and next-to-skin clothing.

This layer is double to form the pockets. There is also an idea of adding an extra barrier layer on the outside to force the surrounding heat to better stay away.

12.2.2.2. Outside

A soft, lightweight, stretchy and durable polyester mesh (Figure 31, top) is chosen to the outside of the product. It is the same material today mostly used in the Cooling Vest.

12.2.2.3. Velcro

Velcro will be used for connection and the closing mechanism. It is cheap, durable and hardwearing. Two widths will be used, the thirty-millimetres male on the strap and the appurtenant forty-millimetre female on the connection area.

12.2.2.4. Edging

A stretchy polyester binding (Figure 31) is added around the section to give the section stability and longer durability.

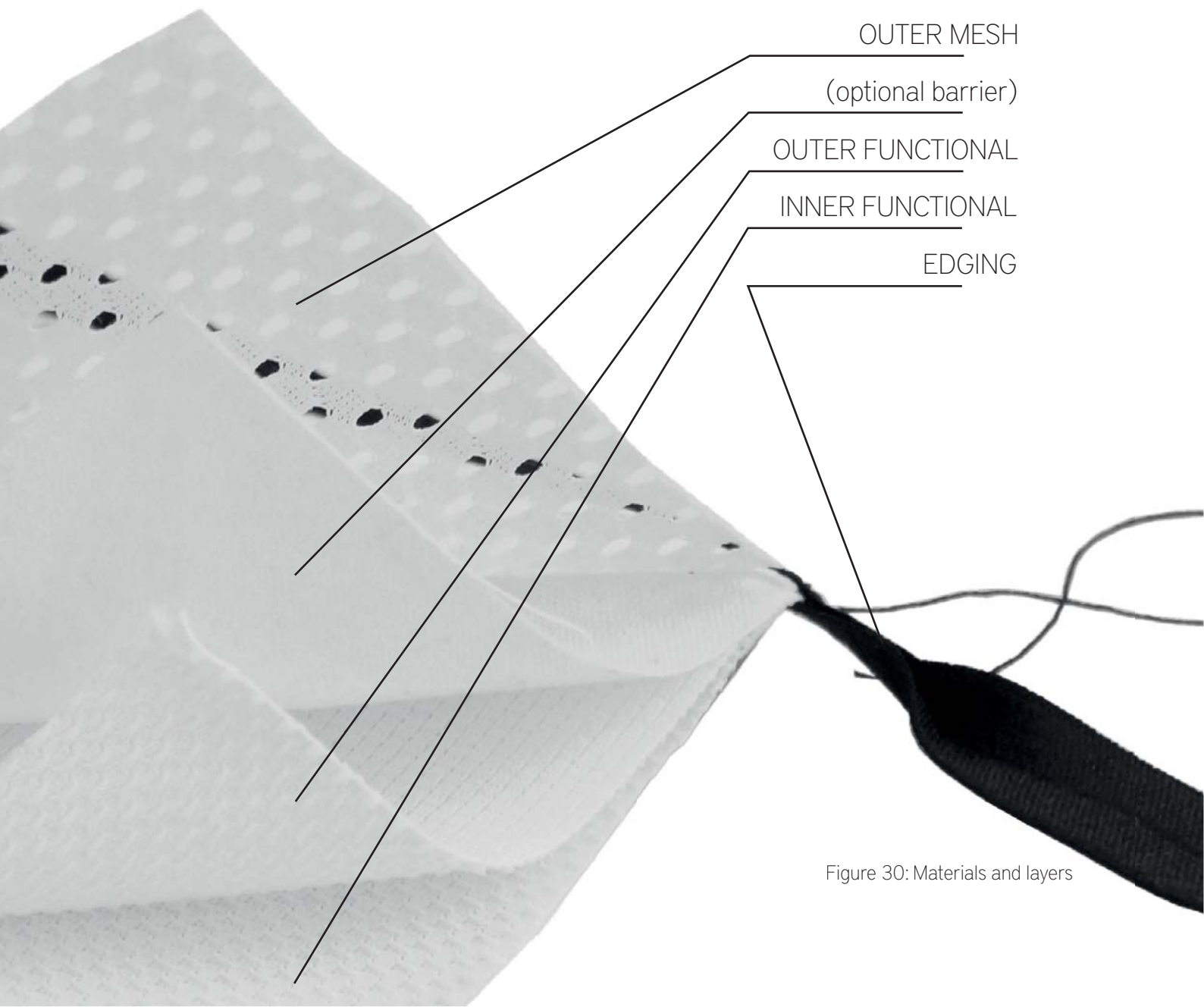
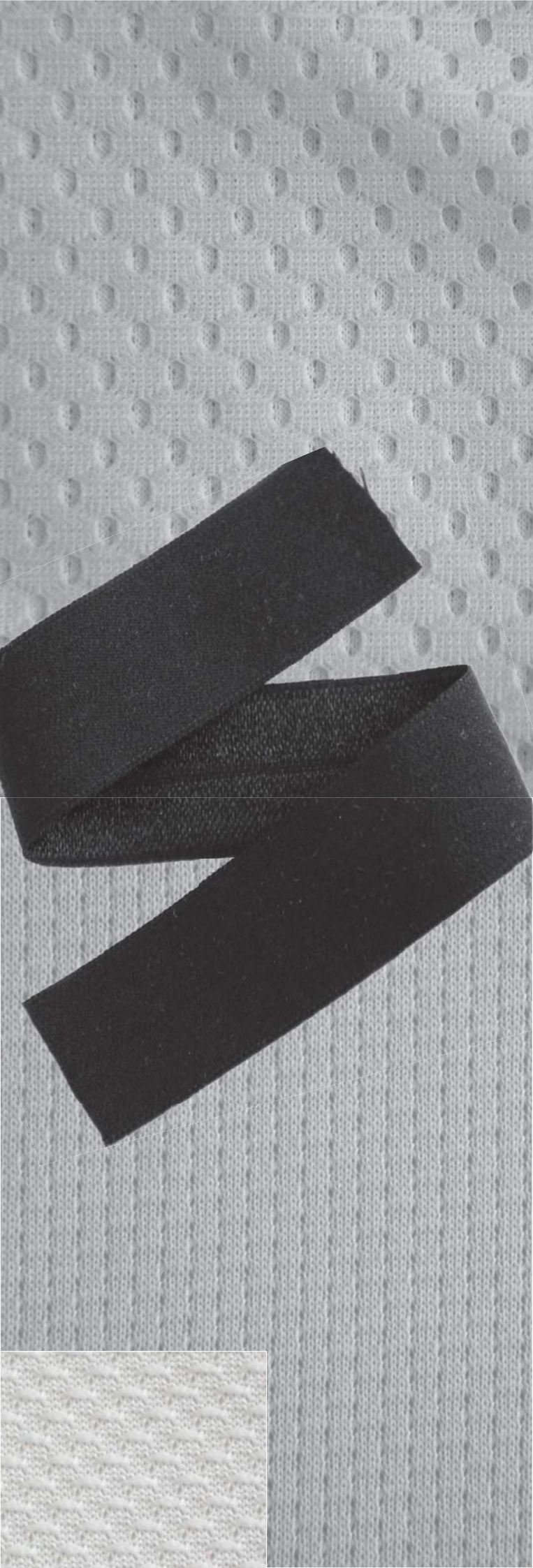


Figure 30: Materials and layers



12.2.3. WEIGHT

Each section weight around 170 grams, where the Temptech element weights 70 grams each and the fabrics adds about 30 grams.

12.2.4. COLOUR

The colour is chosen to be dark enough to not be easily dirtied and light enough to give a cool expression. Two different purple shades and one colour are chosen, where the darkest is placed inside and one on the edging. The lighter colour is put on the outside.

12.2.5. PRICE

First of all, today there is not a unit price on the Temptech elements as these seldom are sold as stand alone products. The Temptech element has been sold individually in some special cases, for example, to the American army. At that time the price was set to 70 Swedish kronor for each element. Another example is the laptop cooler, with six Temptech elements, and a plastic printed cover that cost less than 400 Swedish kronor in retailer shops.

An approximate price for a section with two elements, based on today's margins, would be 140 Swedish kronor for the two Temptech elements and maximum another 20 Swedish kronor for the fabric and Velcro.

A belt of four sections would then cost 640 Swedish kronor. This price is more than half of the minimum monthly income in Indonesia, and too expensive for a cooling product you can survive without. But as the margins in this estimations are very high, also by Swedish standards, a price much more suitable for the Indonesian market should be possible.

Figure 31: Material. From top: mesh, edging and functional

12.3. FINAL CONCEPT : DESCRIPTION OF COOLING BELT

The final concept proposed in this project is a belt (Figure 32, Figure 33, Figure 34 and Figure 35). It is formed by one or more cooling sections, which is described in previous chapter. The belt of cooling sections will be able to cool the waist (high and low), nates, chest, arms and legs, depending on how the sections are combined.

Every section will add 5 centimetres of possible adjustment to the belt, which means two combined sections can be adjusted 10 centimetres and three combined sections can be adjusted 15 centimetre and so on.

The section can be used alone, or as two or more sections combined as seen in the figures. Depending on the users waist circumference, four (sometimes only three) or more sections will be assemble to a belt.

Due to the cooling capacity needed in the investigated environment, the four section sized belt - for the waist or to be placed on a seat - is the main concept proposed in this development project.

The waist placement is the most beneficial when it comes to cooling efficiency and usefulness in a variety of activities.

There are situations when more cooling is needed or cooling of other parts of the body is requested. For these situations, additional sections can be used to form shorter belts for arms and legs. If less cooling is needed, or if a waist belt is not requested, it is naturally possible to use only the arm and / or leg cooling.





Figure 32: Cooling belt for seats, model.



Figure 33: Cooling waist belt, model.





Figure 34: (left) Belt to be placed flat on for example a seat

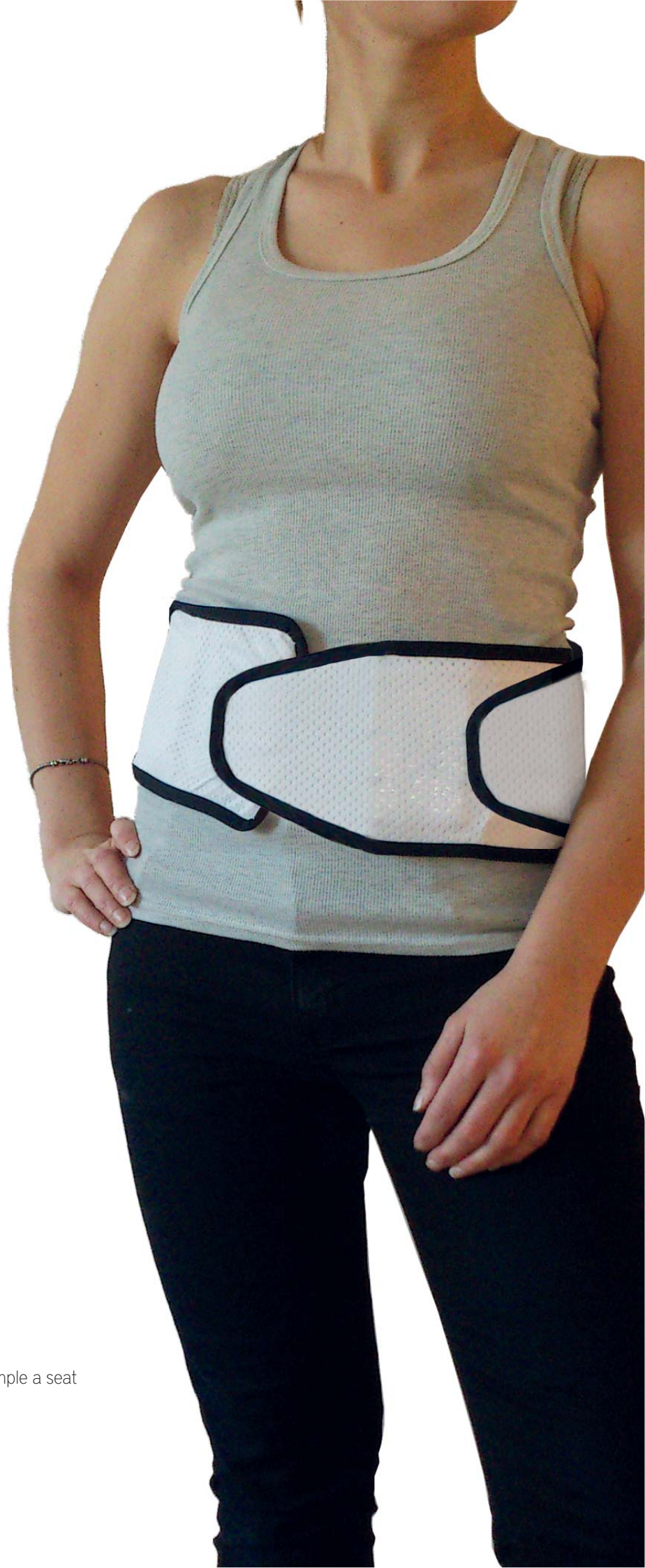


Figure 35: (right) Belt to be worn

13. EVALUATIONS OF FINAL CONCEPT

The final product has not been tested in a tropical climate or in other similar situations, but it has been given to a few people to try out in a sports class as well as in a low tempered sauna (about 40° C). Comments from this session are summarised and presented below.

13.1. SIZE

The section with two elements and a less than ten centimetres strap covers almost all needed lengths, but a longer strap would make the variation in lengths even better and also add a greater adaptability to different part of the body. A longer or different designed strap/connection would increase the possibilities to use it as arm and leg cooler. The tested version needed an additional piece of material to be comfortably used around the arm and leg.

But a longer strap could decrease the simplicity of the section and make it less useful, for example, seat cooler. This has to be taken into consideration when the next version is designed.

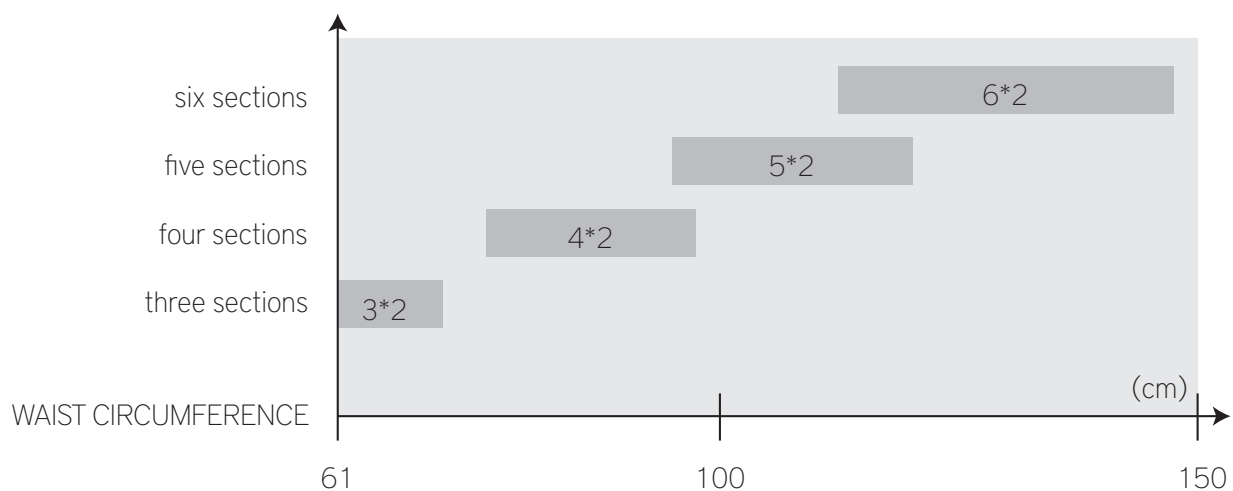


Figure 36: Approximate circumferences and possible belt lengths if formed by either one or two elements sections

13.2. AFFORDABILITY

The cost and business plan have not been included in this project but is an important part before the product is ready for the market.

What has been included and will have an impact on the affordability is; usefulness, durability and user experience.

13.2.1. PRICE

The research and development of this product was done as a student project and does not add any cost. The material and number of elements are kept to a minimum, which results in a simple design that easy to copy.

Today's price on the Temptech element, with high margins and production in Sweden, is very high in relation to the Indonesian average income. It would be possible to produce and sell a product like this on the Indonesian market for a much lower price if TST Sweden has the interest. The product could for example be locally produced and the profit earned on quantities rather than high margins.

The expensive part of the product is the Temptech element. An alternative is that the company looks into the theory of business in emerging country, which has proven to be a good business opportunity, and could be beneficial for a Swedish profit seeking company, as long as they are ready for it.

The great advantage of this product is that it can be adapted for all members of the family or even friends. It can be used in a variety of situations and could either be worn or placed on a surface that is in contact with the body.

13.2.2. DURABILITY

The material chosen, polyester, is one of the most durable in respect to its cost and thickness. It has good qualities that make it easy to wash and keep clean.

Various weather conditions should not be a problem for the durability. It would not be comfortable to wear a wet cooling product, but it would not shorten the products life either. If it is placed in the sun while not in use, it will lose its cooling capacity for that time, but will be ready to use again if 'charged' in colder place.

The elements can be easily taken out. This means that if they for any reason are destroyed they are easily replaced. The fabric will probably be worn out before the elements, but then the fabric is cheap to replace, especially in Indonesia where tailoring is of high quality and low cost.

A critical piece is the Velcro that can be jaded. Another critical material is the aluminium packaging of the element that could rip the fabric apart. But as both Velcro and the combination Temptech element/polyester are used in today's cooling products it has already proved that the durability is good enough.

13.3. FUNCTIONALITY

13.3.1. POCKET

None of the test users have any problems with placing or replacing the elements.

13.3.2. COOLING

In the environment used for the test, the belt gives a nice and pleasant cooling. It cools the body for a relatively long time, about 2-3 hours. The question is if this would be the situation in tropical environment too and if the double layer of material on the outside of the section would be enough.

An outer barrier of a special fabric that keeps the surrounding heat away from the Temptech element could be a good alternative, as long as it does not hinder sweating or make the product uncomfortable or too heavy.

13.3.3. ASSEMBLY OF SECTIONS

The assembly is good. Velcro is a simple and cheap option that is easy to assemble and adjust. The design is simple too, but should be looked upon one more time to improve the usage even more. As it is today a very long belt is flimsy as the material is light and soft and the elements solid and heavy. This could definitely be remedied with small means.

The strap gives about five centimeters of length adjustment to each section with a minimum of material used. It is ok, but it could be worth using extra material and redesign the strap to provide even more length variations and make one-hand adjustments possible.

13.4. COMFORT

The test users did not know they needed cooling but all thought it was nice which means it could definitely be a nice experience and aid use in hot environments too. There were no big complaints about the use, neither to put it on nor to wear it for a long time, from the test users.

The main opinion was that the belt gave less impact than they thought and that no one really thought about it very much while running around. None of the users took the belt away when we sat down, even though it is an alternative.

The test users became sweaty under the belt, and the t-shirt was wet especially where the Temptech elements had been placed and less where the mesh material had been.

13.5. SUSTAINABILITY

13.5.1. ENVIRONMENTAL ASPECTS

The only energy that is used is the one in the production of the Temptech elements, the fabric section and for transportation to the customer. After this initial stage the product has no demand of any external energy for example while in use or to be recharged.

The fabric in the product is recyclable and so is the aluminium cover of the Temptech element. The salt blend is a natural product that does not harm the environment, even though it is best to not waste it but rather collect and reuse.

As an alternative to electrical thermal regulatory products, such as fans and air-conditioning, the product will contribute decreased overall use of energy in homes and society.

13.5.2. HEALTH

A body that is kept within the comfort zone is a healthier body that helps people to keep the energy and motivation on high levels. Happier people are friendlier and will perform at a higher level.

The product will decrease the number of heat related illnesses and therefore save time and money to the user and society.

The possibility to provide cooling to any family member in any one situation is one of the strengths. The product can be used in a variety of situations from worn for work to cool a sick baby. This makes it more worth having than many other cooling products and also more affordable.

13.6. USER EXPERIENCE

The sought expression was cool, comfort and light, of which some are expressed already at first sight and some, such as the comfort, is related to the usage situation.

The coolness is at first sight expressed by light colour, thin mesh material and small size. Later, while the product is in use, it is comfortably given by the element. This cooling is a surprise at first time, that is hard to understand before tried, but later a recognised feeling. The cooling is given at a very comfortable temperature that is almost not noticed after a while, but quickly requested when gone.

The comfort can be seen in the soft and elastic outer fabric and the possibility to be personalised in size and placement. When the solid Temptech element is felt by hand doubt about the comfort is sometimes expressed, but only until the product is tried on. The user then feels the comfort, that is provided by the shape and overall design, when the product is worn or used in other ways.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

14. DISCUSSION

14.1. OVERALL

Indonesia is, in its worst parts, a very polluted and dirty country, and the discussion and awareness of the environment is often scarce. Products that are environmentally sustainable are of great need, but will not be successful if they are not competitive; affordable and better than the alternative. If information and education in environmental questions could be spread with the technology it would be even better.

The introduction of one simple product with the Temptech element could be a beneficial way to make the technology recognized and requested. Other, perhaps locally developed products could thereafter follow. A product like the one proposed can be used for a long time and thereafter given an even longer life by the owner, for example by making new products with the same elements when the covering material becomes worn-out.

14.2. PROCESS

14.2.1. PHASE 1 : PRE-STUDY

14.2.1.1. Literature

The literature study was split in two parts, one part to find and understand the human body and its performance in heat, the other part to find theories, methodologies and tools to be used in the project. I wish I had done a smarter choice in the first, because there is no real research on cooling products in developing country.

14.2.1.2. Market research

The market research was good because it showed me the enormous interest in this kind of product, but also the gaps, especially for product that can be used in humid environment. I did try some other technologies, not in the end very useful for the project, but made me believe in the technology I was working with to a much higher degree.

14.2.1.3. Defining user and context

The user group had to be limited in some way, even if I did struggle with it for a long time, and in the end left if very broad. I found it easier to define situations where a cooling product could be useful and from there find the users than the other way around.

14.2.2. PHASE 2 : ETHNOGRAPHY

The first few days of field study was a shocking awakening - although I was neither new to the country, the culture or language. I found myself in a totally new situation, where the fulfilling human basic needs was not enough but I had to interact with people in specific ways and talk about specific topics. I tried to do it in the way I was used to, where the spoken word is thought to be the most reliable. It was not, and quite early it was clear that observations and self-experience of the situation, in this case, was much more important and useful than planned and structured interviews.

It didn't matter that I got help to find lovely people with interesting stories to tell, because after the many language transfers that it took, from me formulating the question, via the interpreter and to reach the respondent, and the same with the returning answer, there was no depth left. I understood quite early that the method of research had to be changed to add depth to the study. I was not trained in this kind of study and neither was the interpreter. Cultural differences added problems to the situation too. For example were the Indonesians I met at this stage not very used to critical thinking and rather respond with what they thought were the correct answer.

It was not hard to find participants, Indonesians are the friendliest people I have ever met, and I was invited to visit or live with many people on the way. I choose the two main participants of ethnographic study because they could be observed in broad spectra of situations, and because there would be one English speaking person to discuss with at both places. Adi had very good English and so has the oldest son of Sara. Observations combined with informal discussions were the methods that gave most

in this study. I learned that simple is good and often best.

I had quite a lot of discussions with Adi, who has lived in Australia and has travel a bit in other South-east Asian countries. It was his strength that he has been abroad and had experienced other cultures that he could relate to and this gave him a better understanding for my questions. This can have done him very influential in my analysis, but I did confirm my findings with other people too and therefore I think this is not a very big problem.

Although it was hard to find the depth, it was too easy to go broad, everything sounds very interesting until it is time to transcribe and organise it, and it is way too much and take way too long time. Lesson learn - stick to the subject.

14.2.3. PHASE 3 : DEVELOPMENT

The creative phase of this project took off in one specific cooling technology and was further limited to come up with a personal cooling device. These two limitations, plus that there is no way to take away the source to the problem – turn off the sun – made the ideation clearly defined.

It was very interesting to work this way around, to find the possibilities with one defined technology, instead of coming up with an idea and first thereafter find the best way to make it work. I think this is very useful, to make sure the best comes out of new, or not yet wide spread technologies, but that it has to be combined with a user-centred perspective. Even the best technology could be wasted if it is not presented in a useful way.

Methods chosen for ideation was quite simple and straightforward, as a consequence of the limitations the project had. Methods were chosen to help the ideation become structured. Methods generating too fuzzy ideas was never requested because it felt too far away from the cooling element / personal device criteria limitation.

The evaluation, with just me filling in the evaluations forms felt as the result could be too much influenced by my personal view and favourite idea, but because I was aware of it I could try to avoid it as much as possible. On the other hand, I was very comfortable in my role, because I am very aware of the situation for the user group, the needs and requests.

I used the morphologic matrix as a method for structured development of the chosen idea, which I think was very useful and simple, but it does not support the evaluation, which could have been good. On the other hand, at this step there were full-scale models to test, which evaluated by experiencing and exploring rather than by any theoretical method.

14.3. FINDINGS

Product potential

The cooling elements, produced and sold by a Swedish company, are expensive seen from an Indonesian economy. My hope is that TST Sweden takes a look in the research of emerging market and understands its potential. An other alternative is that a company or farm owner, for example, will buy the cooling products to the employees, which is not impossible due to the rise of economy makes it harder and harder to find people that are willing to do the hardest and warmest work. It is not yet seen in Indonesia, but the neighbour country Malaysia have started to see a trend where the hardest (hottest) job is not longer very easy to find workers to, because with growing economies better opportunities comes for the poorer too. Therefore this could be a way to protect the worker and provide a better work environment that makes people interesting in the job again.

The cooling product is adapted for one user group, but will have a great potential and be suitable for a much larger group of people, not deeper investigated in this study but in urgent need of environmentally friendly and effective cooling, without need of electricity and that can be worn in active situations. Athletes, disabled, actresses, ill, motorcyclist are just to mention a few. Another group that was not looked into is children, but by the proposed solution it will be possible to adapt it for them as well. Older people is often mentioned as the one suffering worse in the heat waves, I believe this is a product that could help them too. People travelling the world, for example business (wo)men, aid workers and tourists could definitely need this cooling product.

The Temptech elements have another advantage, which is that they are very good as warming elements too. This means that product has a even greater market than discussed in this thesis. A warming belt could be as useful as a cooling belt, both on emerging market and in other countries.

I did not limit the ide generation to keep the price of the product low, although that is a requirement on an emerging market, but I rather wanted the ideation to be as free as possible to find the best product and in the evaluation be able to find the overall most useful and affordable product. I am glad that I did, because the business has greater possibilities with a good product than a product that compromise with the quality and functionality.

14.4. MINOR FIELD STUDY

There are two sides of the Minor Field Study funding; the generous money contribution and the single country demand. Where the first made it possible to carry out a field study on the emerging market, the second required adherence to one specific country, which is not the normal case for a product development project.

The demand on in-depth study of one country, instead of scratching the surface of many different ones, was in the end very beneficial for the project. I learn that it takes time to get to know people and understand differences in culture, at least to a level where it is could be the key to success in the development of a needed and requested product.

I am very grateful that I was given the opportunity to do a field study, not only because it strengthened the project itself but also because of all wonderful people I have met and the things outside the study I have learnt.

The Minor Field Study, the ethnographic study, did add values to my education that I could never learn in Sweden. I feel that the obstacles I met in a new culture and a new country not only broaden my understanding for people in other countries and of other socio-economic backgrounds.

15. CONCLUSION

Cooling is definitely needed in Indonesia, in various situations and by various people. Cooling is especially needed for people that perform their daily chore or work in environment – outdoor, indoor or semi-indoor - where it becomes very warm during sunny hours and the hours following these. Often heat cannot be avoided and is a thermal condition Indonesians have to learn to live with and endure to earn their living.

- *How should a personal cooling product be designed to be affordable and suitable for users suffering in hot environment and at the same time maximise the cooling given from the Temptech elements?*

The proposed cooling product, the waist belt, is affordable, better and cheaper than other cooling products available today. It is simple to use, repair and keep clean, which are important on the Indonesian market.

The advantage of the Temptech element is that one element is better than none. The proposed product takes advantages of this and is possible to be used for cooling from the first bought cooling element, as it can be fitted around the arm. The capacity is best preserved and used by a product that has a tight fit, which the belt has with its stretchy material and adjustable sizes. The final cooling product could come as one product, that can be used in many ways to fit different user sizes and usage situations. It could also be sold as single sections, which could be combined to every buyer's own choice and economic situation.

Indonesia is a country that is in a great need of sustainable products and sustainable educations. A product like Temptech could absolutely be a part of that, and would be an option both cheaper and greener than other cooling sources, such as air-conditioning, and it can be used where no artificial cooling will ever reach, such as on rice fields and market places.

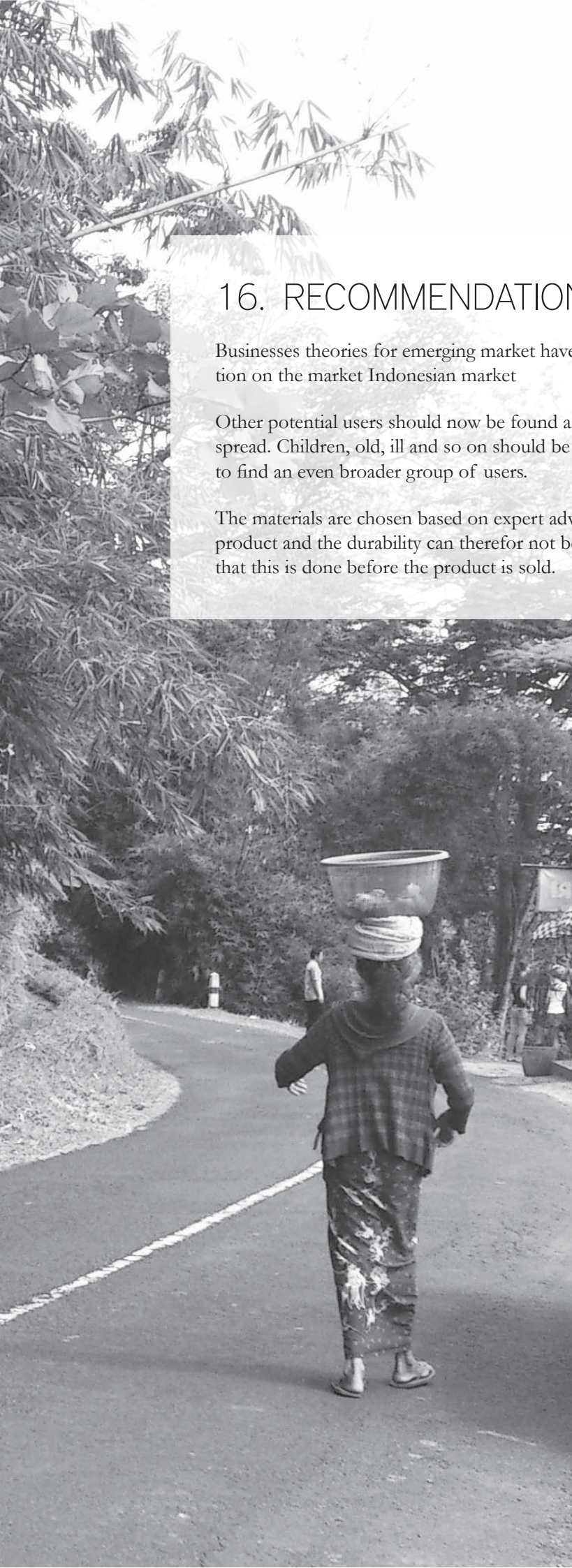


16. RECOMMENDATIONS FOR FURTHER WORK

Businesses theories for emerging market have to be understood before an introduction on the market Indonesian market

Other potential users should now be found and the advantages of this product spread. Children, old, ill and so on should be asked to test and evaluate the product to find an even broader group of users.

The materials are chosen based on expert advice but have not been tested in this product and the durability can therefor not be guaranteed. It is a recommendation that this is done before the product is sold.



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APPENDICES

18. APPENDICES

18.1. APPENDIX I

WAYS TO REDUCE HEAT STRESS

ADAPTING ACTIVITY LEVEL

- A well-planned cycle of activity and rest allows the skin to dry off and the body to cool down
- Lowering the intensity of activity
- Avoiding physically activity at midday
- Decreasing the duration of activity in heat
- Work or do activity in team, then more people will be able to notice sign of beginning heat stress

BEHAVIOURAL CHANGES

- Seek cooler surroundings/shaded spot
- Turn off unnecessary lights, TV, oven, fans so they do not produce heat
- Drink water
- Avoid caffeine and alcohol
- Eat cool things such as frozen berries and ice creams
- High protein diet improves thermoregulatory capacity
- Go for a swim
- Wear your hair up

MEDICAL

- Learn/Know the signs and symptoms of heat to be able to take action
- Good physical fitness increase the thermoregulatory capacity

- Acclimatisation
- Gradually exposure to heat gives the body time to adapt to the heat

CLOTHING

- Exposure a larger skin area
- Loose-fitting clothing allows the air to circulate next to the skin
- Thin clothing in naturally fabric allows better evaporation
- Wear light coloured clothes
- Keep the back of your head in shade
- Misting a light layer of water in your skin or wet parts of your clothes has instant cooling effect
- Wear clothing that excess moisture from lying on the skin surface

ENGINEERING CONTROLS

- Install fans
- Shielding from radiant heat sources
- Wear a cooling vest / use cooling products

18.2. APPENDIX II

COMPETITOR ANALYSIS

18.2.1. COMPETITOR ANALYSIS : PROCESS

A Competitor Analysis can be used in the early part of a product development process to identify strengths and weaknesses of competing products. It will explore how typical tasks are achieved and how parts are designed in these products. The goal is to use this information to predict competitor behaviour, planned actions and strategies, but also to develop an improved product that better achieve the users need.

First step is to find competitor products that is already on the market and satisfies the same user need as the current project is interested in. Next step is to carry out the analysis. All competitor products are analysed against a set of criteria, based on the users, tasks and context that is important for the specific user need. Finally the statement of conclusion from the analysis session is summarised. (<http://www.usabilitynet.org/tools/competitoranalysis.htm>)

18.2.2. COMPETITOR ANALYSIS : FINDINGS

Competing products to be used in the competitor analysis was found in different Internet based shops, some specialised in cooling products, other in sports equipment or medical aids. Temptech cooling

element, Water-based cooling element and products cooling by evaporative cooling were collected and investigated. User experience of other investigated technologies were collected in blogs, forum and articles on Internet.

First part of the analysis was to summarise background fact available for each chosen cooling technology. Next step was to gather data about how a user experienced and judged it, both its cooling capacity and comfort.

The Competitor Analysis is used to find and understand advantageous and weaknesses in different cooling technologies. It is the user experience of different technologies rather than the style and design of a specific product that is of interest in this stage of the project. Therefore the Temptech cooling element, rather than the Cooling Vest, is used as a reference product for the analysis against other cooling technologies on the market.

No competitor has been found to use the same technology and temperature of cooling as the Temptech cooling elements. All vests come in different sizes and designs, but it is the technology that is investigated rather than the comfort of the clothing design.

Four main categories of cooling technologies were found; salt-based solid to liquid phase change material (Cool58™), water based phase change material (KoolMax™), evaporative cooling activated by water (Evaporative Cooling Vest) and cold gel (Arctic Heat Cooling Vest).

Table 18: Summary of competing products

	CHARGING / READY TO USE	COOLING TEM- PERATURE	COOLING TIME (32°C)	WEIGHT	COOLING EF- FECT	COMFORT IN USE	LIFE CYCLE	PRICE	CLEANING
Cool58™	2h / instant	14.5°C	2-3h	3.4kg	Medium	Solidified	Years	1500SEK	Desinfection / water
Evaporative vest	10 min in water	<26°C	minimum 45h	1-1.5kg	Low	Soft gel	12-18months	300SEK	Only water
Arctic Heat Cooling Vest	15 min in water	Various	30-60min	1kg	Medium	Soft gel	Years	1800SEK	Washable in soapy water
KoolMax™	2h / instant	0°C	3-4h	1.7-2.5kg	High	Solidified	Years	1000SEK	Desinfection / water
TST SWEDEN'S COOLING VEST	4H / INSTANT	28°C	MAXIMUM 4H	1.6KG	HIGH	SOLIDIFIED	YEARS	2100SEK	DESINFECTION / WATER

18.2.2.1. COOLING VEST TST-SWEDEN

STRENGTHS

- Long product life cycle
- Up to four hours cooling in one charge
- Instant ready (if room temperature is under 24°C, or stored in other cold place)
- Cooling temperature (28°C) very comfortable and advantageous for the body
- No condensed water because works above the dew point
- Effective cooling in all climates
- Washable
- Non-toxic and non-flammable
- Interchangeable packs (change to new set)
- Environmentally friendly use and charge phase

WEAKNESSES

- Need a room temperature under 24°C or cold tap water, otherwise other cold storage for charging
- If not stored in freezer an hour to charge
- Relatively heavy
- Heavy to carry extra packs for longer lasting cooling
- Cooling packs are solid when frozen
- Works best with a functional t-shirt under and a covering garment on top

USER EXPERIENCE

- Best cooling effect for heavy work in very warm and extreme work environment, but comes to the cost of weight and price that is not suitable for all users

18.2.2.2. COOL58™

Cool58™ is a vest has pockets for phase change cooling element that freeze solid at 58°F (15°C) in a fridge and cools the body when it uses energy (heat) to change back to a liquid phase.

STRENGTHS

- Long product life cycle
- Instant ready if stored in fridge
- Cooling temperature (15°C) is within comfortable level
- Effective cooling in all climates
- Washable
- Non-toxic and non-flammable
- Interchangeable packs (change to new chilled set)
- Environmentally friendly use phase

WEAKNESSES

- Needs fridge, freezer or bucket of ice water to be frozen
- If not stored in freezer an hour to charge
- Relatively heavy
- Heavy to carry extra packs for longer lasting cooling
- Cooling packs are solid when frozen (?)

USER EXPERIENCE

- High cooling capacity, but to the cost of weight and price

18.2.2.3. EVAPORATIVE COOLING VEST

The Evaporative Cooling Vest has closed pocket with crystals that when soaked in water transforms to a gel. The gel cools when the stored water evaporates to the surrounding air.

STRENGTHS

- Ready to use in 10minutes, but the cooling effect increase to the second day
- Long lasting cooling effect, minimum 45hours (in 38°C)
- Light weight
- Natural cooling, environmentally friendly
- Adjustable to the shape of the body
- Inexpensive compared to other cooling vests
- Cooling temperature (15-26°C) is within comfortable level

WEAKNESSES

- Needs water to be activated
- Normally last for 18month, but if carefully handled it lasts longer
- Works best in low-humidity climates
- Must not be used under heavy clothing (?)
- Have to be fully evaporated before stored in airtight situation to prevent mould
- Not washable in washing powder or similar
- Leaves a moistures feeling on the cooling spot
- If over-soaked gel may force it way through material and makes the skin feel sticky
- May absorb bacteria

USER EXPERIENCE

- Light weight and inexpensive cooling for dry climate that reach a moderate cooling level

18.2.2.4. ARCTIC HEAT COOLING VEST

The Arctic Heat Cooling Vest has pockets for packs containing viscose gel. The gel is placed in either cold water or in other cold place of preferred temperature and cools the body with the stored cold.

STRENGTHS

- Ready to use in 2-15minutes, depending on temperature requested
- Environmentally friendly cooling
- Adjust its shape to the body
- Washable in soapy water
- User chose the cooling temperature
- Interchangeable packs (change to new chilled set)

WEAKNESSES

- Requested temperature last for maximum 2hours, after that the temperature will increase slowly until equalized with ambient temperature
- Needs cold water, fridge or freezer to be activated (? Annars rumstemperature som tst..)
- Have to be fully evaporated before stored in airtight situation, this to prevent mould
- Expensive \$129 for set of four packs

USER EXPERIENCE

- Prized by many for its high cooling capacity compared to other vest with same weights, but it comes to the cost of high price.

18.2.2.5. KOOL MAX™

KoolMax™ is a vest with pockets for water-based cooling packs. The packs are charged in the freezer and then used to cool the body.

STRENGTHS

- Last for years
- If packs are kept in freezer they are instant ready when needed
- Cooling last for 3-4hours
- Effective cooling in all climates
- Possible to keep extra set of packs in freezer to always have more cooling ready
- Washable packs
- Biodegradable materials, non-toxic water-based cooling
- Naturally cooling, no carbon dioxide waste while in use
- High cooling energy for moderate costs

WEAKNESSES

- Needs freezer
- Cooling temperature may cause cold burns
- If not stored in freezer takes hours to get ready
- Heavy to carry extra packs for longer lasting cooling
- Cooling packs are solid when frozen
- Water condense on the cooling packs
- Interchangeable packs (change to new frozen set)

USER EXPERIENCE

- High cooling capacity for quite long time and to a nice price, but on the heavy side

18.3. APPENDIX III

ETHNOGRAPHY PLANNING

(Sent to the University of Surabaya)

18.3.2.1. GOAL

- As many interviews and observations as possible
- Personas and Scenario for the User Group
- Result and analyse of working situation and working experience
- A deep understanding for Indonesian culture and social life
- Special understanding for medical service in Indonesia
- A list of need, demands and requirement for user and context
- At least a few ideation sessions
- If possible one idea chosen
- Ready to start the product development when back in Sweden
- Context
 - × Architecture
 - × Work tasks
 - × Colleagues
- Physical work environment
 - × Temperature
 - × Air movement
 - × Humidity
 - × Fan
- Clothing
- Any temperature regulation equipment; fan

18.3.1. WHAT I AM LOOKING FOR

18.3.1.1. NON-EXTREME SITUATIONS

- Assessment of heat in work situation; nice, ok, problematic?
- Work situation
 - × Working hours
 - × Rest
 - × Temperature
 - × Intensity
 - × Stress

18.3.1.2. HOSPITAL / MEDICAL SERVICE

- Assessment of heat at work; nice, ok, problematic?
- Style of hospital / medical service / child care home (Indonesia)
- Represented professions
- Illnesses especially suffering in heat; high fever, Multiple Scleroses?
- Clothing

18.4. APPENDIX IV

INTERVIEW TEMPLATE

18.4.1. CLIMATE

How would you describe the climate?

How would you describe the heat?

What does the heat mean for your everyday life?

What is best with the heat?

What is worst with the heat?

What climate would you prefer to work in?

18.4.2. WORK ENVIRONMENT

Do you work in a hot environment?

- Is it nice and good for your work?
- Or, does it make your job harder?

What is the best about your work environment?

What is the worse about your work environment?
Heat or something else?

Is it the heat itself or what the heat do with your
body (physical or psychological) that is the worst
part?

Is it an option to work slower when it is hot?

Do you adjust your work intensity depending on if it
is hot or not?

18.4.3. CLOTHING

What does your clothing look like a normal workday?

- What kind of material do you prefer to wear
in heat? Silk, cotton, synthetics?
- What model / style do you prefer to wear in
heat? Loose fitting, thin, covering?

- Is it up to you what you wear on work or
do you follow any rules? Company, cultural,
religious?

What does your clothing look like when not at work?

Would it be ok to use an extra layer of clothing if it
was cooling you?

What area of your body if often warm?

Have you ever assessed the difference between
clothing covering all your body and those covering
as less as possible? Short arms versus long arms for
example.

Have you ever covered more of your body than you
like to and the weather demands?

- How do you feel about that?

Are you wearing hat or similar? Why and what type?

18.4.4. HEAT STRESS

Do the heat affect your work capacity / perfor-
mance?

Have you experienced any symptom of heat stress?
Headache, dehydration, tiredness, irritation or any-
thing else?

How does your body react on heat?

Do you perform physical work in heat?

Are you working in the hottest hours of the day?

- What time is that?

Do you work with the same intensity all day?

Do you ever take rest to avoid hottest hours?

Have you seen someone suffering in the heat?

- In what way?

Do you believe that you can work harder when it is
colder? Why?

18.4.5. ADAPTION TO HEAT

How do you change your behaviour if it is a really warm day?

Do you do anything special to beat the heat?

Have you ever worked in a air-conditioned place? Do you like it? Why / Why not?

If a very good cooling product was available on the market, would you use it?

- How much do you think is a good price for this kind of product?
- Could you afford that?

18.4.6. REFLECTION

The global heating may cause a rise in temperature (1-3°C) here in Indonesia, do think that would affect you and your work?

Most of the economical developed countries are in the tempered zone, and most of the economic under-developed zones are in the tropical and warm climate zone. Why do you think it happens to be so?

Thank you / elin

18.5. APPENDIX V

ASSESSMENT WORKSHEET

HARI INI / TODAY

cauca / weather



pakaian / clothes

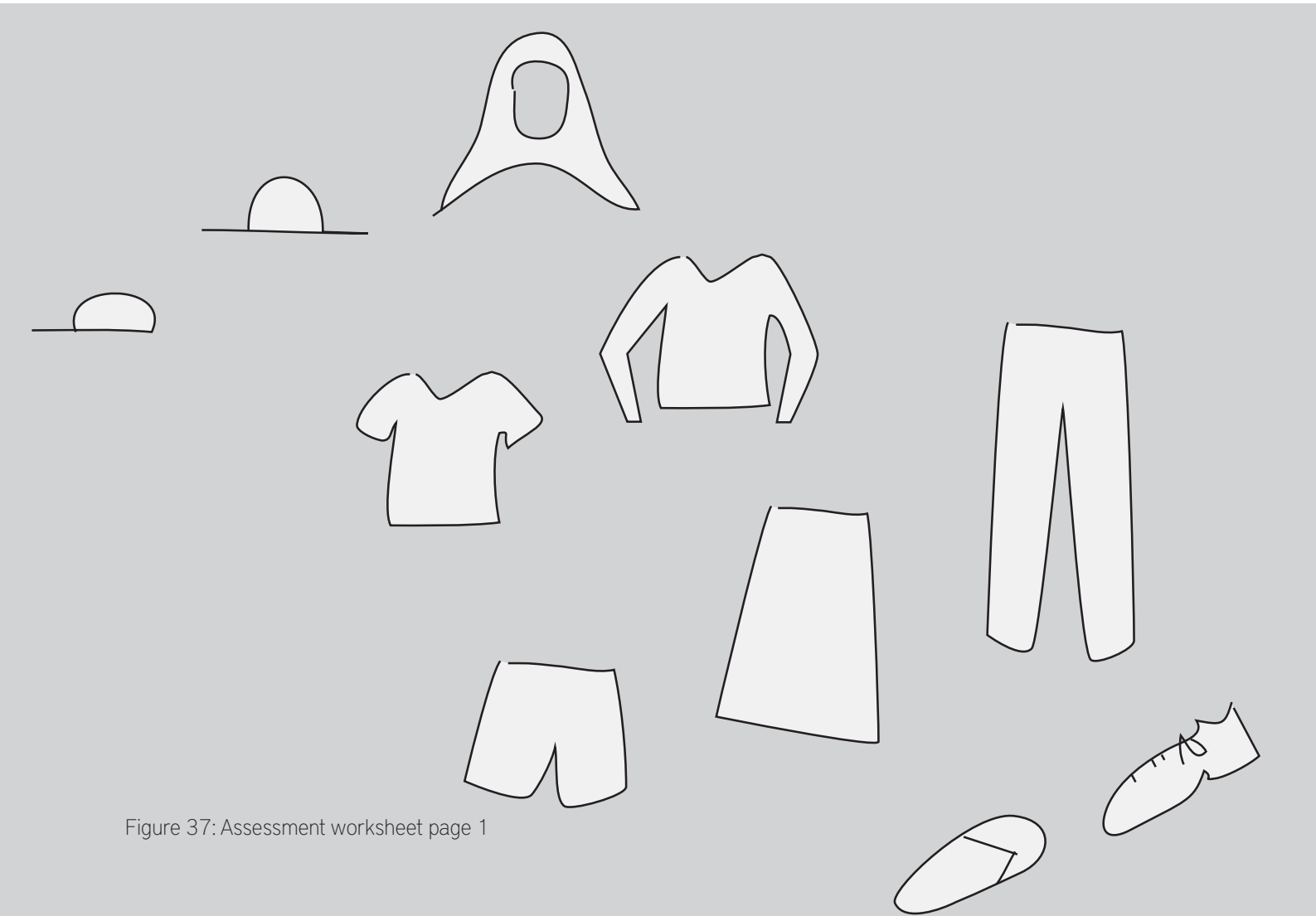
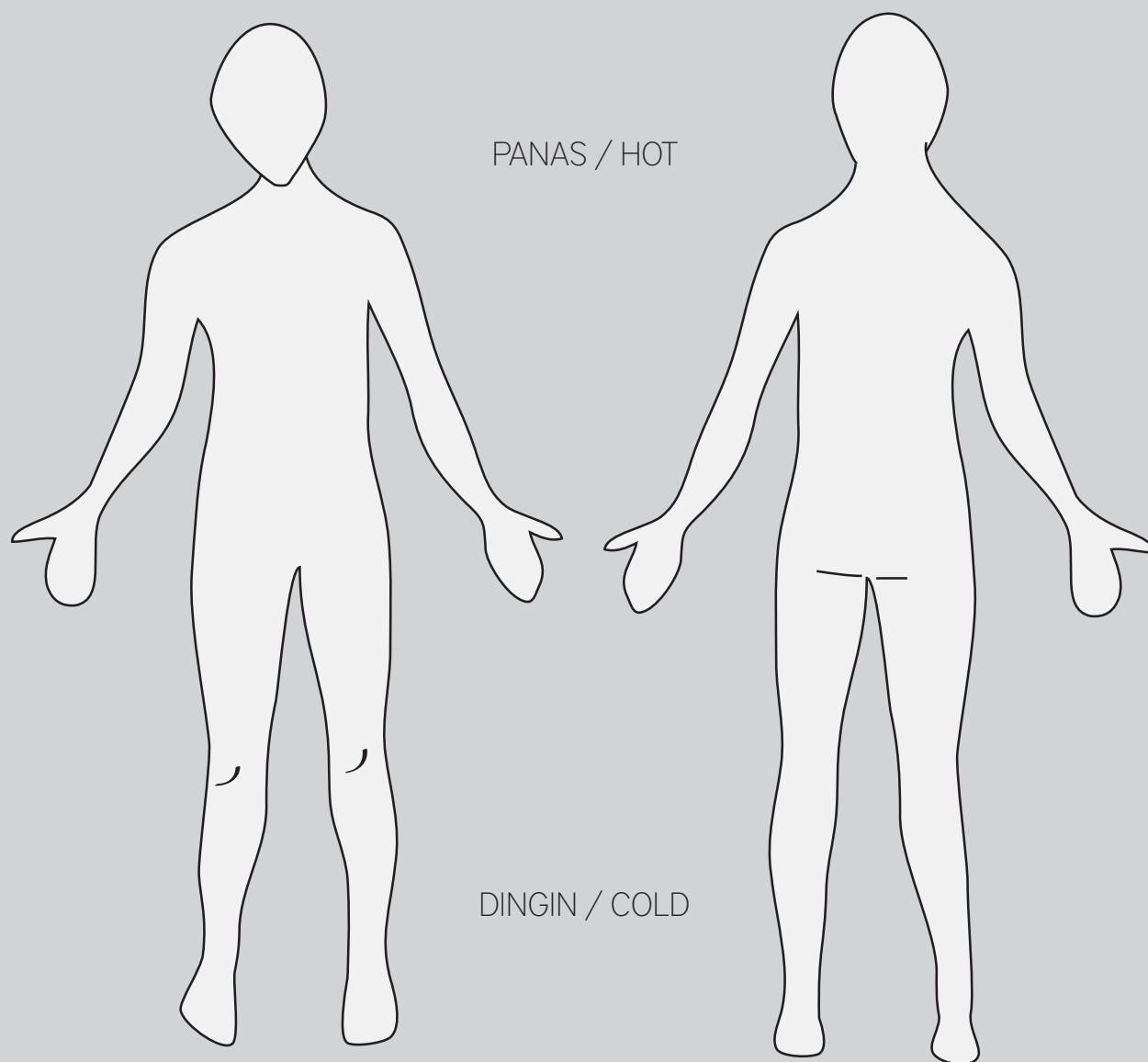


Figure 37: Assessment worksheet page 1

DEPAND DAN KEMBALI / BACK AND FRONT



PILIHAND ANDA / YOUR CHOICE



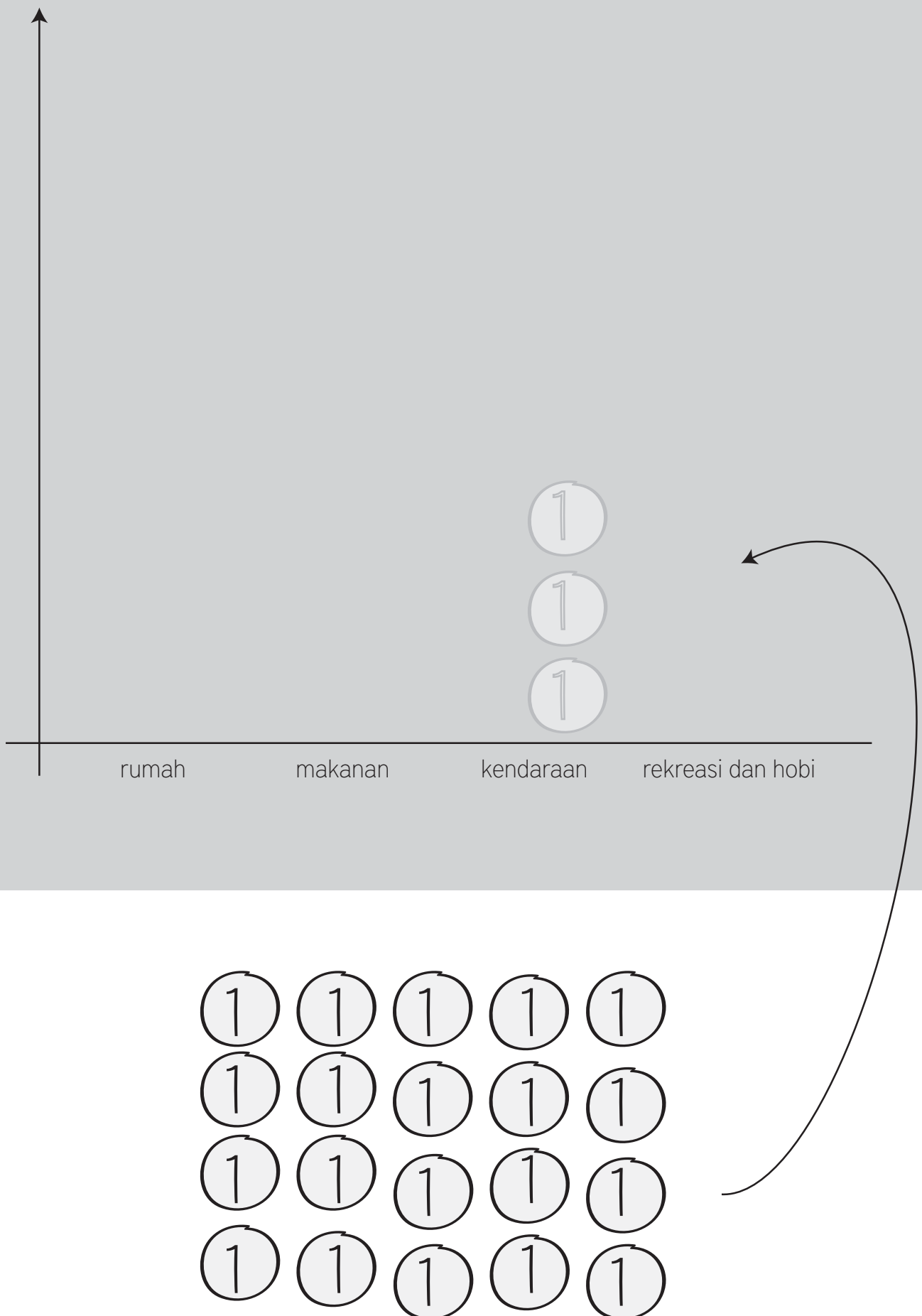


Figure 39: Assessment worksheet page 1

18.6. APPENDIX VI

REQUESTED PRODUCT QUALITIES

18.6.1. FEATURES (FUNCTION)

- Good cooling capacity
- Low weight
- Function in diverse hot environment / contexts
- Function in diverse hot use situation
- Cooling without feeling to cold
- Possible to use in sun
- Allow replacement of cooling element
- Adjustable placement of cooling element
- Allow airflow close to body
- Possible to use without additional clothes under or over

18.6.2. FEATURES (DESIGN)

- Attract people to try / want / use the product
- Adopted to the use context / situation
- Positive emotions – spread smiles
- Allow customization (different colour?)

18.6.3. ERGONOMICS

- Good ergonomic
- Easy to carry
- High liberty of action / no restriction of body movement
- Improved living and / or working situation
- Comfortable in active life and / or relaxing
- Possible to sleep with

18.6.4. USABILITY

- Easy to get ready to use
- Easy to store
- Easy to clean
- Easy to replace cooling element
- Intuitive understanding for first time users

18.6.5. ECONOMY

- Low price
- Long lasting / Good quality
- Withstand sun / sweat / water / dirt

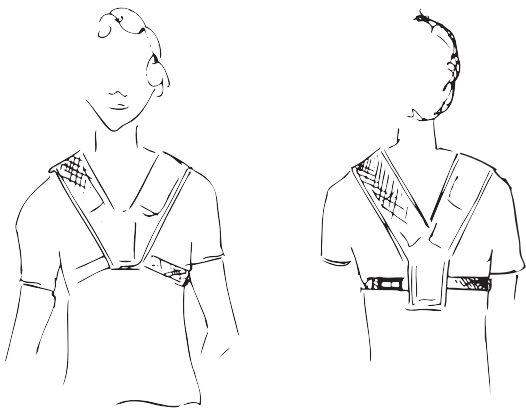
18.6.6. HYGIENE

- Pleasant smell
- Easy to wash
- Quick dry from wash / rain / sweat

18.7. APPENDIX VII

PROS AND CONS

ACTIVE



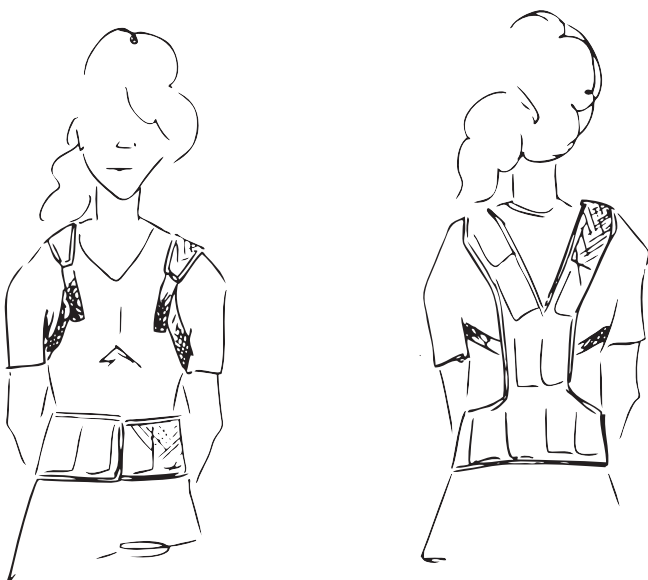
- + lightweight
- + simple
- + low prise

- loose fit
- low cooling capacity
- small cooling area



- + simple
- + good cooling area
- + possible to choose where to cool
- + tight fit
- + no interference of movements
- + easy to store

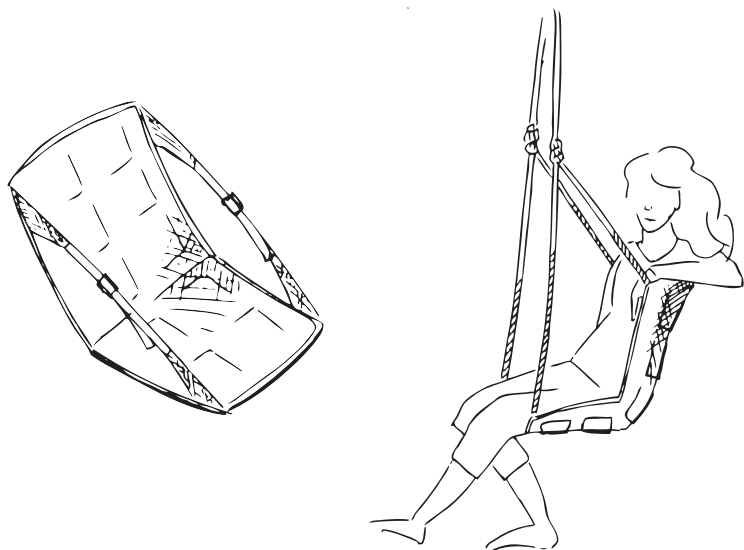
- no upper back cooling



- + cooling back and front
- + tight fit
- + no interference of movements

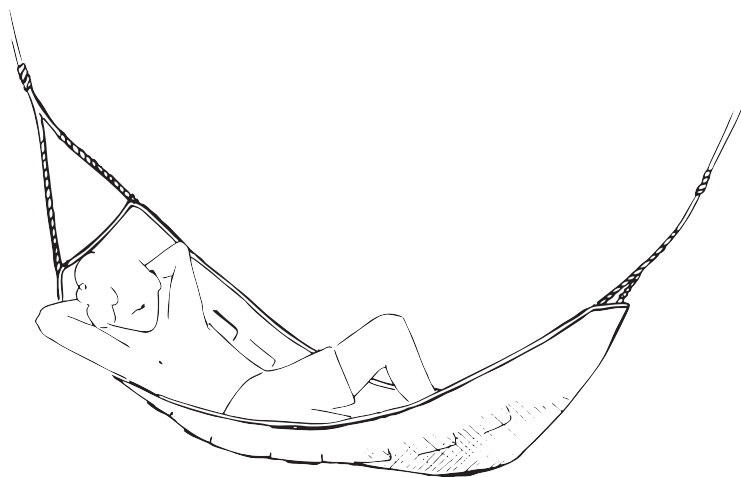
- more complicated
- one way to use
-

RECOVERY



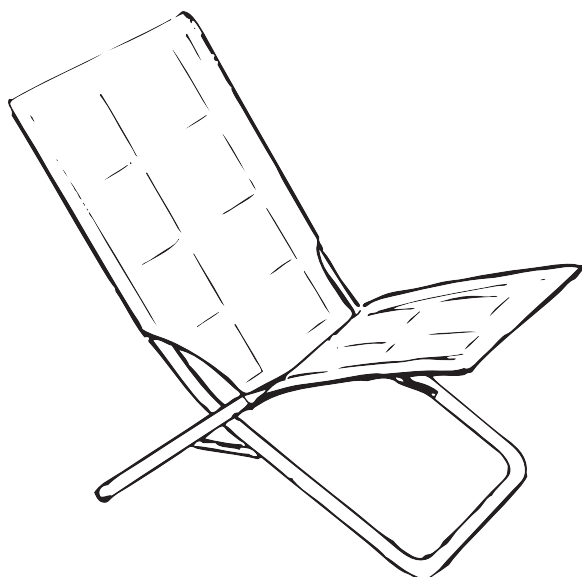
- + large cooling area
- + ready to use
- + elements in shade
- + stored in cool bag

- cover large area
- on the ground
- tiring for neck
- extra weight to bring



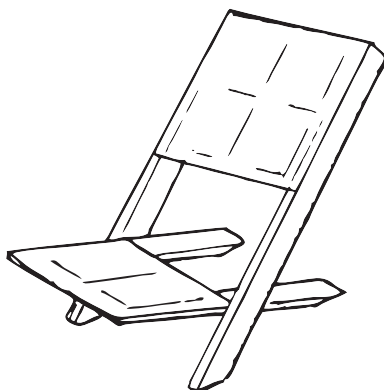
- + large cooling area
- + elements in shade
- + relaxing
- + stored in cool bag

- cover large area
- suspension
- heavy
- extra weigh to bring

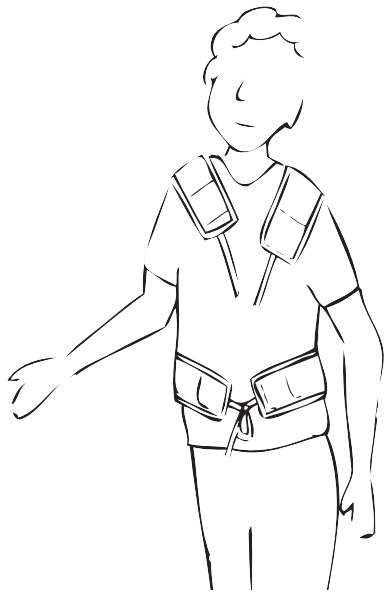


- + large cooling area
- + above ground
- + comfortable seating

- cover large area
- heavy
- extra weight to bring
- not able to put in bag

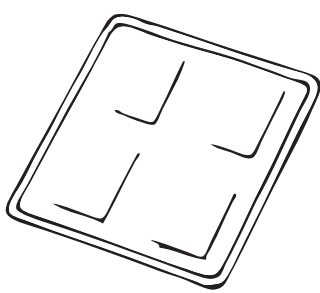


SIMPLE



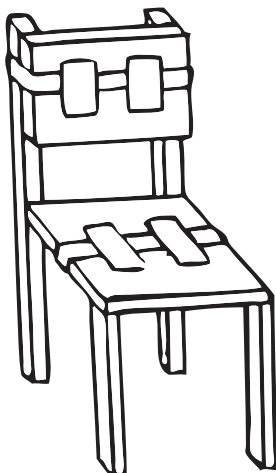
- + affordable
- + flexible placement
- + simple to use
- + low weight
- + stored in cool bag
- + can be used both for body and seat

- small cooling area
- low cooling capacity



- + affordable
- + simple
- + same idea - many sizes
- + low weight
- + small
- + can be put on hot seat

- small cooling area
- low cooling capacity



- + large cooling area
- + possible to adapt
- + many possibilities

- loose parts

