Final report

EPS spring 2020

Mirka

LCA of coated abrasive products and alternative waste usage

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Acknowlegdment

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AC	Actual Cost
CPI	Cost Performance Index
CV	Cost Variance
EPS	European Project Semester
EV	Earned Value
EVA	Earned Value Analysis
FU	Functional Unit
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
LCI	Life Cycle Inventory Analysis
PC	Planed Cost
SPI	Schedule Performance Index
SV	Schedule Variance
TBSC	Technobothnia services concepts
kgkm	kilogram kilometre
tkm	ton kilometre

1. Introduction

1.1 Background

Climate change and environmental pollution are increasingly relevant issues today. The temperatures are rising, the poles are melting and as a result, sea levels are increasing. With sustainable production, companies can contribute to reducing these effects. In particular, the energy-intensive industry has a major influence on emissions and climate change. To achieve the goal of sustainable production, several suitable tools and methods are available. One of them is Life Cycle Assessment (LCA), which is a tool for identifying and evaluating the environmental impact of a product, process or service. The focus of this project is on creating an LCA for a finnish company called Mirka, who is a world leader of sanding solutions for surface finishing. A detailed definition of LCA can be found in chapter 2 of this report.

Mirka is looking for solutions regarding two different issues. The primary target of the project is the creation of an LCA with the focus on the functionality of the software SimaPro. The team is assigned to create an LCA for two different products to demonstrate which conclusions can be drawn by using the software. The secondary aim of the project is to investigate new solutions for reusing the large amount of waste generated during the production process. This report mainly demonstrates how the team proceeded in the creation of an LCA and what needs to be considered when using SimaPro.

First the report presents introductions of Mirka as well as Technobothnia Service Concept (TBSC), the owners of the project. In addition, information about the European Project Semester (EPS) and the project itself are provided. Subsequently, a theoretical chapter follows, in which the foundations of an LCA are explained in detail. Afterwards, a description is presented of the process of creating the LCA followed by a presentation of the results. The second part of the report provides ideas for the alternative usage of the waste. Finally, the results are summarised and recommendations to the company are presented.

1.2 Introduction of the company Mirka Ltd

Mirka Ltd (Mirka) is a global manufacturer and world leader of sanding solutions for surface finishing, especially coated abrasives that allow dust-free surface finishing. The company has subsidiaries all over the world. The head office and the production are located in Finland. The products considered in this project are produced in Jeppo, Karis and Oravais. The company has in total over 1400 employees worldwide and in Finland the number of employees is 700.

Mirka was founded in 1943 and is part of the KWH Group. It manufactures products especially for the automotive, wood and boat industry and exports 97 % of its products to over 100 countries.

1.3 Introduction of Technobothnia Service Concept

Technobothnia Service Concept (TBSC) is the second project owner for this project. Its main objective is to improve the connection between the education sector and the regional businesses. To reach this goal, TBSC promotes the technobothnia laboratories not only as a teaching and investigation environment, but also as an innovation and test environment at the service of the companies. In order to achieve this objective, an inventory of the needs and an analysis of the potential stakeholders will be created. These will be supported by information gathering opportunities and workshops. Out of this basis of communication and information, a plan will be created. In addition, based on the previous identified needs, a virtual collaboration platform will be developed in order to respond to this plan.

1.4 Introduction of European Project Semester (EPS)

European Project Semester (EPS) is a program developed and offered by several European universities to students who have completed at least two years of study. It was created with engineering students in mind, but other students who can create an added value in an engineering project are also welcome to join. EPS is a mixture of “Project Related Courses” and project organised and problem-based learning. For example, here at Novia the EPS group has the following courses: Project Management, Team Building, English and Swedish. The program is made to prepare students with all the necessary skills to face the challenges of today’s world. Students work in teams of three to six students who come from several countries and have different study fields. Projects are done in cooperation with commercial businesses and industries or with research centres. (European Project Semester)

A few key elements of EPS are:

- Semester lasts 15 weeks minimum
- EPS is project centred
- Working language is English
- Main focus in EPS is teamwork

1.5 General objectives

Mirka always attaches high value to a sustainable production, which is why their mission is not to waste any resources. Therefore, the primary target for the EPS team is to create an LCA for the company by using the software SimaPro. The definition of an LCA is given in chapter 2. SimaPro is a tool for collecting, analysing and monitoring data to assess the sustainability performance of products and services. The main objective for Mirka is to gain an insight into SimaPro to determine if it is suitable for the company. In order to examine the functionality of the tool, two different products will be analysed and assessed.

The secondary target of the EPS project is about the usage of waste. During the production of the sanding discs, 3 905 550 kg of waste is generated per year, which is currently burned. The EPS team will investigate possible usages for the waste and find business ideas. Within the scope of this task, possibilities for material recovery processes are to be found. In appendix A the production of traditional sanding paper is displayed in a chart.

2. Life Cycle Assessment

2.1 Introduction

Life Cycle Assessment (LCA) is a way to assess environmental impacts of a product, process or activity throughout its life cycle which means from the very beginning (the extraction of raw materials) untill the very end (disposal after use). An LCA is convenient because it shows both the general overview and the details. For example, the carbon footprint and other environmental impacts for products in general can be measured and at the same time it is possible to quantify the impact of a single material. Furthermore, an LCA is highly efficient because it can be completely automated. Just by using the input data, it will create a reliable report that measures the most demanded environmental impacts. Since an LCA relies on international standards, it can objectively compare alternatives. (Heijungs)

2.2 Theoretical foundations about Life Cycle Assessment

2.2.1 Definition of Life Cycle Assessment

An LCA is, according to ISO 14040 and ISO 14044, a tool to compile and evaluate the input and output flows and the potential environmental impacts of a product system over its life cycle. ISO 14040 and ISO 14044 are international standards for creating an LCA. A whole analysis includes all steps from raw material extraction to the end of life (see Figure 1).

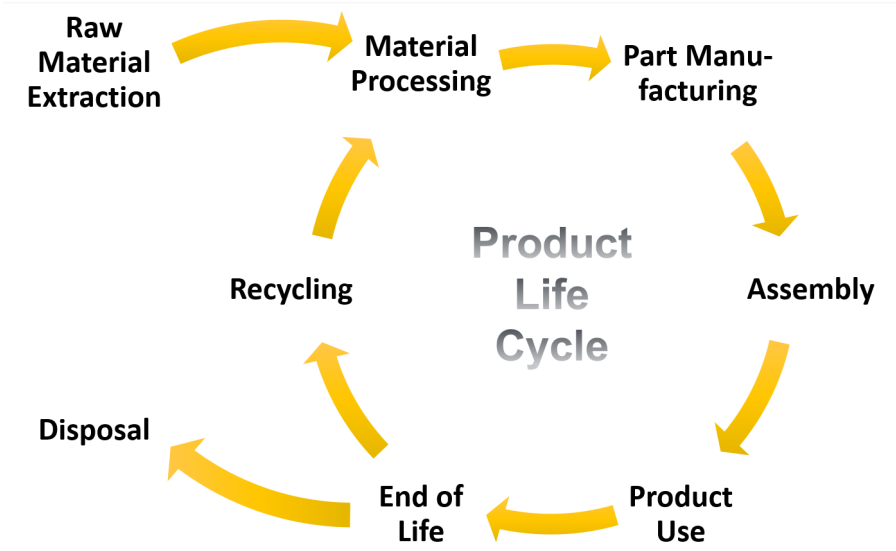


Figure 1: Product life cycle (own figure)

The purpose of an LCA is to assess all environmental impacts of a product, starting with the extraction of the raw materials and ending with the waste management. An LCA can also be created for a process or a service, not only for a product. By considering a product over its entire life cycle, a shift of burdens can be prevented, for example a shift between the phases of the life cycle or between different regions. Consequently, the LCA is a suitable tool to avoid shifting problems. Furthermore, an LCA over the entire life cycle ensures that all environmental impacts outside the company are also considered. (Finnveden, Klöpffer)

2.2.2 Components of a Life Cycle Assessment according to ISO 14040

According to ISO 14040, an LCA consists of four parts (also see Figure 2):

- Goal and Scope Definition
- Life Cycle Inventory Analysis (LCI)
- Life Cycle Impact Assessment (LCIA)
- Interpretation

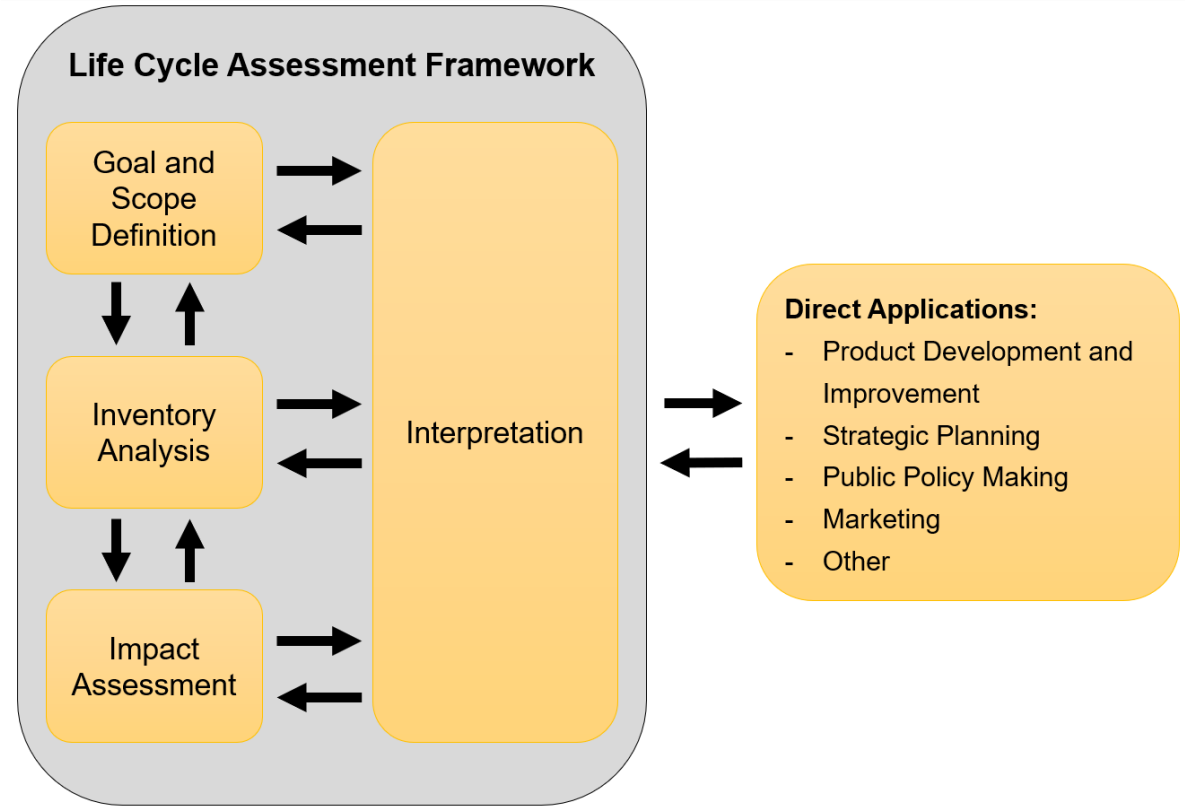


Figure 2: Components of an LCA (own figure, adapted from: ISO 14040)

Goal and scope definition

This part represents the beginning of an LCA. It describes the product system and contains the reasons and the motivation for conducting the LCA. Moreover, it defines the intended audience and what the assessment is to be used for. The goal and scope definition also includes the impact categories, the limitations and the system boundaries, which are important to limit which processes, locations or products are considered. It is also necessary to specify which input data are required. (Finnveden)

Another essential component of the scope definition is the functional unit (FU), which must be chosen individually and depending on the function of the analysed system. “The functional unit is the important basis that enables alternative goods, or services, to be compared and analysed.” (Rebitzer) For instance, the FU can be area-based (e.g. m^2) or volume-based (e.g. m^3). (Gabriel)

Life Cycle Inventory Analysis

The Life Cycle Inventory (LCI) includes a compilation of all inputs and outputs of a product throughout its life cycle. In this context, the input consists of all resources, for example energy, materials and fossil fuels. Outputs are for example emissions into the atmosphere, waste or material outputs (products). (Finnveden) The LCI is the basis for the following Life Cycle Impact Assessment. (Gabriel)

Life Cycle Impact Assessment

The Life Cycle Impact Assessment (LCIA) helps to interpret an LCA and enables to identify and evaluate the size and significance of possible environmental impacts of a product system over the products life cycle. Environmental impacts are for example global warming, greenhouse effect or acidification of soil and water. (Finnveden) For this purpose, all inputs and outputs are classified into impact categories, which is realised by using characterisation factors. These factors specify the environmental impact per unit, for example per kilogram of resource or emission. (Huijbregts)

There are several methods of impact assessment. The most common ones are the methods ILCD (recommended by the European Platform on LCA, EPLCA), ReCiPe and CML-IA.

In conclusion, in the LCIA the product life cycle is evaluated in relation to several impact categories, such as global warming, ozone formation or acidification. (Rebitzer) Chapter 2.2.3 explains the LCIA in detail.

Interpretation

The interpretation is the final part of an LCA. The relevant issues related to the goal and scope definition are identified by analysing and structuring the results of the previous phases. Furthermore, the study itself must be evaluated, for example by checking if it is complete. (Zampori) The purpose of this phase is to draw conclusions and recommendations. (Finnveden)

2.2.3 Impact categories and characterisation factors

In the following the LCIA and its most relevant steps for this project are explained in detail. One essential step is the classification, in which all required emissions and resources from the LCI are allocated according to the environmental impact. For example, the emissions CO_2 and CH_4 are allocated to the environmental impact “greenhouse effect”. Subsequently, a characterisation is conducted, which means that impact category indicators are calculated. For this purpose one reference emission is selected and the remaining emissions are described on the basis of this reference. In the example of the greenhouse effect, CO_2 is used as reference and is therefore set to: $CO_2 = 1$. The remaining emissions are now expressed in CO_2-equivalents, for example CH_4 = 30 kg CO_2-equivalents. This means that CH_4 contributes 30 times stronger to the greenhouse effect than CO_2. It is important to note that the equivalents depend on the considered time frame. If 20 years are considered, then CH_4 = 85 kg CO_2-equivalents. In contrast, if 100 years are assumed, CH_4 = 30 kg CO_2-equivalents. (ifeu) In conclusion, the CO_2-equivalents are used to identify how much a gas contributes to the greenhouse effect. This approach is analogous for all categories (for the categories, see below).

In general, characterisation factors can be derived using two common methods: at midpoint or endpoint. Using the midpoint method means that the characterisation factors are derived “somewhere along the impact pathway”. (Huijbregts) The midpoint indicators concentrate on single environmental problems, such as acidification or global warming. Characterisation factors at the endpoint level classify the environmental impact into one of three areas of protection which are human health, ecosystem quality and resource scarcity. The main difference is the following: the midpoint characterisation has a closer relation to the environmental flows and is generally associated with a smaller parameter uncertainty. The endpoint characterisation is easier to interpret, especially concerning the relevance of the environmental flows. For example, the method ReCiPe includes harmonised characterisation factors at midpoint and endpoint levels. ReCiPe is a damage-based method. (Huijbregts)

Figure 3 displays the impact categories in ReCiPe2016 method and their relations to the areas of protection.

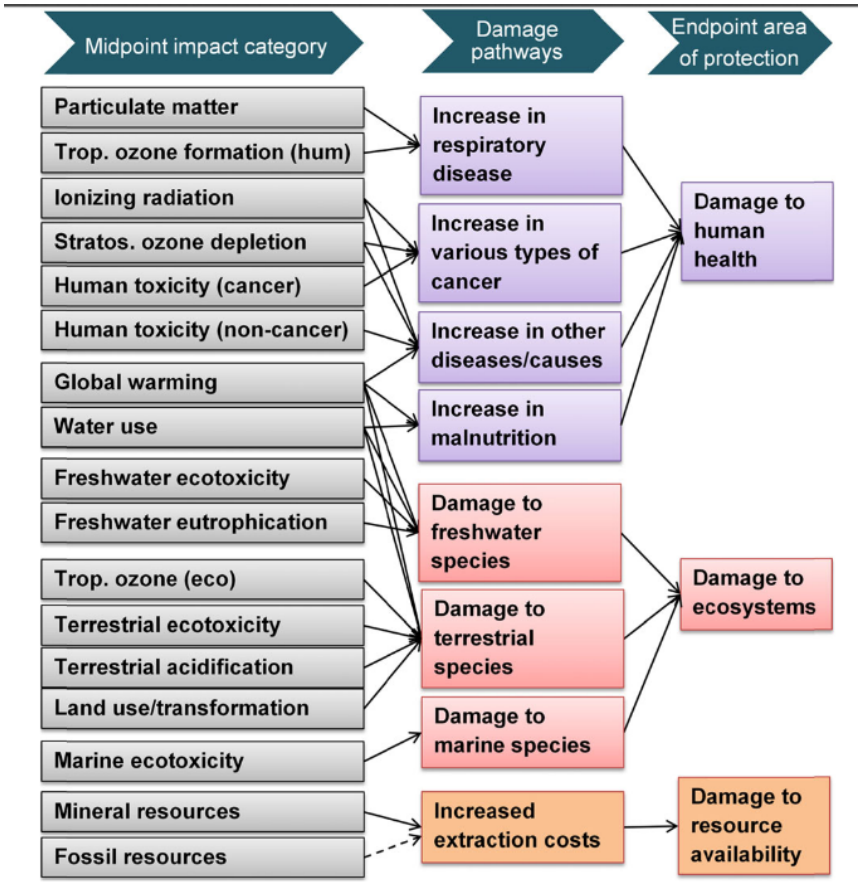


Figure 3: Impact categories in ReCiPe2016 method and their relations to the areas of protection (Source: Huijbregts)

Midpoint categories

In the midpoint method the following impact categories are used in this project: (ifeu)

- Global warming
  - kg CO_2-equivalents;
  - emissions of greenhouse gases: e.g.: carbon dioxide (CO_2), Methane (CH_4), Nitrous oxide (N_2O), CFC
  - "effect of increasing temperature in the lower atmosphere."
  - it shows the direct and indirect environmental impacts of anthropogenic warming of the earth's atmosphere. The emission of anthropogenic greenhouse gases cause an increase in the radiative forcing and to an unbalanced radiation balance of the earth → greenhouse effect

- Stratospheric ozone depletion
  - kg CFC-11-equivalents;
  - This category represents the anthropogenically caused reduction of the stratospheric ozone layer. The ozone molecules in the stratosphere absorb shortwave UV radiation. If the dynamic balance between ozone formation and depletion is disturbed, the amount of UV radiation at the earth's surface increases. This shortwave radiation damages natural resources and human health.

- Ozone formation
  - "Ozone and other reactive oxygen compounds are formed as secondary contaminants in the troposphere (close to the ground). Ozone is formed by the oxidation of the primary contaminants VOC (Volatile Organic Compounds) or CO (carbon monoxide) in the presence of NOx (nitrogen oxides) under the influence of light." (ESU-services)

- Terrestrial acidification
  - kg SO_2-equivalents
  - describes the modification of the acid-base balance of terrestrial ecosystems through emissions of acidifiers and acids.

- Freshwater eutrophication
    - kg PO43-equivalents
    - describes the excessive supply of plant nutrients
    - The consequence of increased nutrient supply is increased plant growth. An overproduction of biomass can affect the balance of food chains, which may have consequences for animals, plants and the functioning of ecosystems.

Endpoint categories

In the endpoint method, following damage categories are shown:

- Human health
    - Unit = DALY (disability-adjusted life years)
    - DALY (disability-adjusted life years) is the most commonly used metric when it comes to damage assessment and it takes into account the years lost to early death and it also expresses the reduced quality of life due to illness in years. (World Health Organisation)

- Ecosystems
    - Unit = species.yr
    - The unit species.yr is a scale for how many plants and organisms are expected to disappear as a result of the executed activities. The number of species will increase again if the origin of this extinction is halted (for example: if the company shuts down). For example: 40 species.yr indicates that for one year 40 species are extinct or four species for 10 years. If in the next year, the assessment for the company would be redone and the result is 30 species.yr, this would indicate that 10 species will begin to reappear again. (SimaPro)

- Resources scarcity
    - Unit = USD2013
    - “This expresses the surplus costs of future resource production over an infinitive time frame (assuming constant annual production).” (SimaPro)

2.3 Materials and Methods

2.3.1 Goal and scope definition for the Life Cycle Assessment

Mirka always attaches high value to a sustainable production, which is why their mission is not to waste any resources. Therefore, the primary target is to create an LCA for the company by using the software SimaPro. The main interest of Mirka is to gain an insight into SimaPro to determine if it is suitable for the company. They will investigate which software could be used in the future and which information they can get from the software. In order to examine the functionality of the tool, two different products will be analysed and assessed. The first product is the “Abranet” sanding disc, which is a premium product (see Figure 4) and the second one is the conventional paper sanding disc “Gold” which is the traditional product from Mirka (see Figure 5).
After making the LCA, the goal is to investigate if there are any differences between the two products. In the end the team will deliver results which the company can continue to use.

Figure 4: Product “Abranet” (Source: https://www.axminster.co.uk/mirka-abranet-abrasive-discs-150mm-ax851133)

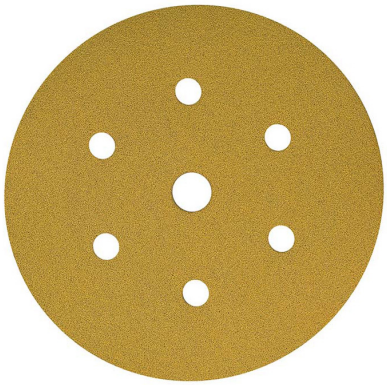


Figure 5: Product “Gold” (Source: https://www.krueckemeyer.de/fileadmin/Redaktuere/Produkte/Mirka/23628_002.jpg)

Impact categories

Since the LCA is primarily intended to demonstrate the functionality of SimaPro, the team selected six impact categories: global warming, stratospheric ozone depletion, ozone formation human, ozone formation terrestrial, terrestrial acidification and freshwater eutrophication. These categories are explained in chapter 2.2.3.

System boundaries

As mentioned before, an LCA describes the environmental impact of for example a product throughout its life cycle. This means that the system boundaries for a complete LCA should be set at the very beginning (the extraction of raw materials) and at the very end (disposal after use). Since every stage of the products life is taken into account, an accurate, complete and detailed outcome will be generated.

In contrast, it is also possible that a company/organisation is only interested in a specific part of the life cycle. Therefore, not all stages will be taken into account, for example: one option could be to only consider the use and the disposal/recycling of the product. As a result, the outcome will not represent a whole LCA, which needs to be taken into consideration while interpreting the results.

It is up to the client who is requesting the LCA to decide where the system boundaries will be placed. For this project, Mirka has set the boundaries as follows: The analysis begins at the supplier of the raw materials and ends at the transport to the warehouses. Everything that happens before and after that is not considered.

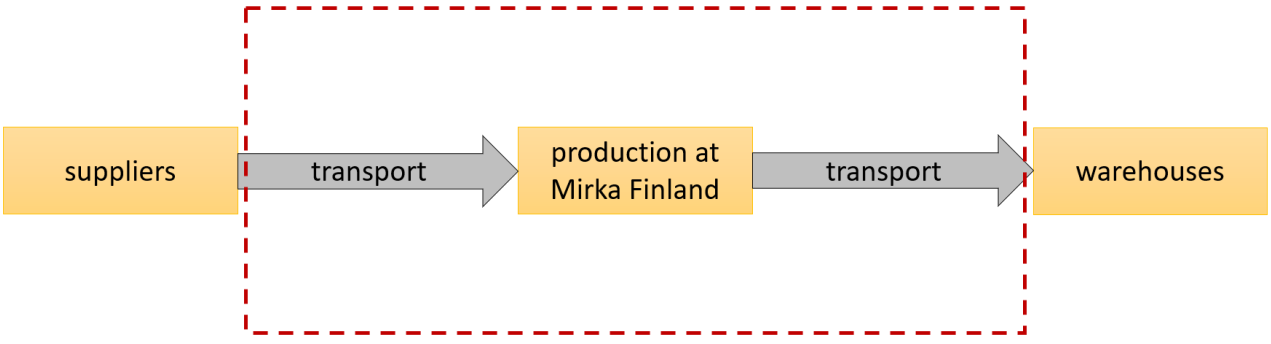


Figure 6: System boundary (own figure)

Functional unit (FU)

In order to analyse and compare the two products, an FU needs to be defined. The definition of an FU can be found in chapter 2.2.2. First, the team considered the following options:

- one m² of final product
- one piece of final product (disc)

It turned out that both options were not optimal. If one m² is chosen as FU, since the finished product is a disc (circle), it is rather difficult to bring the one m² in relation with a certain amount of discs. Therefore this is not the optimal option. By using one unit of product, the impact on the environment would be so low that the interpretation of the results would be complicated.

Finally, the team decided to choose the following as FU:

- 1000 pieces of final product (discs)

By considering 1000 sanding discs as FU, the two production lines can be compared and the results can be clearly illustrated as well as interpreted.

2.3.2 Data collection, calculations and data quality

In general, the basis for making an LCA is data collection. Before starting with modelling in SimaPro, a list of all required input and output values was prepared (see Table 1). The table is categorised into energy inputs, material inputs, emissions into atmosphere, waste, liquid effluent and material output. With the help of this list, the team started collecting data from the company. The division into three processes was an example, since at the time the table was created, the team did not have any information about the number of processes in the factories.

values of environmental aspects (e.g. for 1 piece or for 1 ton …)

environmental aspects	process 1	process 2	process 3	packaging / dispatch	transport
energy inputs (MJ)					
electrical energy					
fossil fuels					
thermal energy (heat)					
material inputs (raw material) (kg)					
paper					
textile					
water					
glue or sth. similar)					
grains					
paint for printing					
packaging material					
emissions into atmosphere (kg)					
CO2					
…					
…					
waste (kg)					
waste from gaps					
waste from holes					
liquid effluent (kg)					
…					
…					
material output (products) (kg)					
sanding disc					
…					

Table 1: Required input and output values (own table)

Provided values from Mirka

A closer analysis of the cross-section of sandpaper indicates six different layers (see figure 7). For example the backing material for “Gold” is raw paper, which is delivered from the supplier as a roll and is called “jumbo roll” in this report. The backing material for “Abranet” is yarn, which is first converted to a textile web in a knitting process.

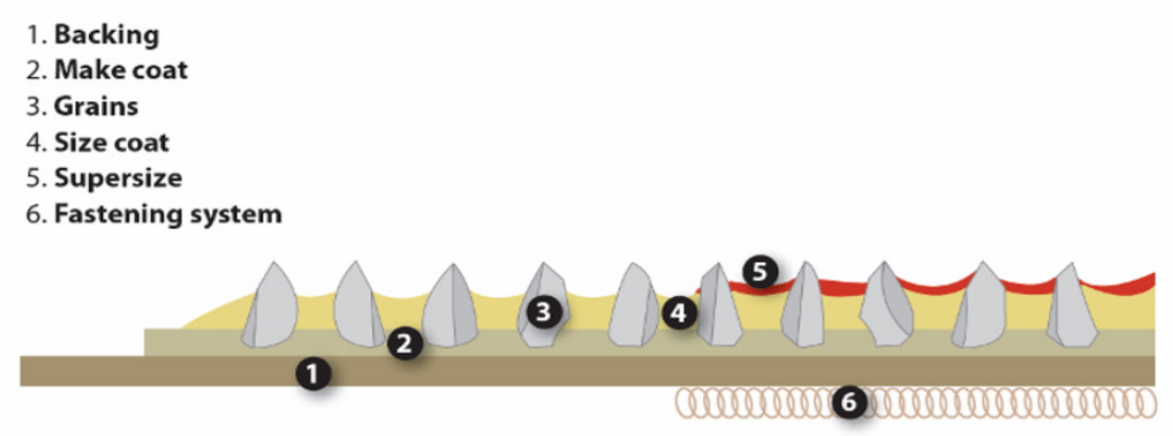


Figure 7: Layers of a sanding disc (Source: Mirka)

The following information was provided by the company:

• The names of the materials, that are required for each layer

	1	2	3	4	5	6	7
Sample	**Backing material**	**impregnation**	**Make Coat**	**Grain**	**Size Coat**	**Super size**	**Fastening system Grip**
Paper (Nr. 1)	10960 PAPER	43235 LATEX	43320 UREA Resin	44483 Al2O3/SiC	43202 PF	Ca Binder: Latex	27907 PA/PET
Textile (Nr. 2)	14750 PA	43202 PF	43204 PF Resin	44153 Al203/SiC	43204 PF	Ca Binder: Latex	Integrated in backing material

Table 2: Materials for each process (Source: Mirka)

• The weight of each layer (minimum and maximum; Since “Gold” and “Abranet” are product families, different kinds of discs are produced within one family. Therefore, the weight depends on the size of the disc and the grid size.)

Product family	Backing IMPGR. MIN [g/m²]	Backing IMPGR. MAX [g/m²]	Backing MIN [g/m²]	Backing MAX [g/m²]	Make Coat MIN [g/m²]	Make Coat MAX [g/m²]	Grain Coat MIN [g/m²]	Grain Coat MAX [g/m²]	Size Coat MIN [g/m²]	Size Coat MAX [g/m²]	Grip Velour [g/m²]	Super size Coat MIN [g/m²]	Super size Coat MAX [g/m²]
textile products	115	145	165	325	5	35	10	170	7	116	0	3	8
Paper products discs		7	90	165	5	50	10	264	20	205	55-70	10	25

Table 3: Weight of each layer (Source: Mirka)

• The names of the processes as well as the location of each process (see appendix B)

• The total electricity and heat consumptions as well as the CO_2 emissions for each factory per year (can be found in appendix C)

• Suppliers: the country and city where the raw materials come from and the type of transport (can be found in appendix D)

• Warehouses: the country, city and type of transport (can be found in appendix D)

• Majority of the heat (steam) is produced by burning wood chips mixed with our coated abrasive waste. As back up energy source biogas can be used.

• Mirka has an energy recovery system: they cover a part of their energy consumption by burning their own waste and recovering the heat.

Provided values from Mirka	Value	Unit
Diameter of the discs	150	mm
Amount of discs per meter jumbo	60	pcs
Width of jumbo	1460	mm
Converting waste (geometrical waste[1])	25	%
Burnt coated abrasive waste annually	3000	ton
Energy content from the waste	20-30	%
Energy consumption per produced square meter	2.6	kWh/m²
Production volume of “Gold” per year	1300000	m²
Production volume of “Abranet” per year	346000	m²

Table 4: Provided values from Mirka

After the company had provided all available data, the missing values needed to be calculated or estimated, in case a calculation was not possible. In appendix F, all values are listed. The excel sheet will be handed over to the company in order to provide the responsible employees an overview of which data is required for SimaPro and how the team collected this input data.

[1] geometrical waste = the waste due to the gaps between the discs

Calculated values

In order to model the LCA in SimaPro, a large number of values needed to be calculated, because not all required values for SimaPro were available.

Calculation of energy and emissions

As shown in appendix C, energy consumptions as well as CO_2 emissions were calculated, based on the input values from the company. It is important to mention that there are no sub-meters for the various processes or machines in the company. There are main energy meters, so the company could provide data for the total energy consumption of the factories. The following values for energy consumption were provided by Mirka: energy consumption per produced square meter, total electricity and heat consumption for each factory per year and production volume of “Gold” and “Abranet” per year. Since the energy consumption per produced square meter combines electricity and heat consumption in one number, the team calculated new values in order to split the total energy into electricity and heat. It is important to note that the team has made the assumption that the given value for energy consumption per produced square meter is the same for both “Gold” and “Abranet”. This means that it was assumed that the energy consumption is 2.6 kWh per square meter for each product. Furthermore, the company provided the values for the total CO_2 emissions. To determine the specific values for the two products “Gold” and “Abranet”, the total production volume in the factories was calculated first. With the total CO_2 emissions and the production volume, the CO_2 emissions for “Gold” and “Abranet” were calculated.

Calculation of size, weight and distances

In addition to energy consumptions and emissions, the values for size and weight of the sanding discs were calculated based on values given by Mirka. Furthermore, the distances from the supplier to the factory and from the factory to the warehouses were calculated. One should note that all values are rounded.

In order to calculate the weight of one m² of sanding paper, the provided weight of all layers (see Table 3 above) were summed up, resulting in the following values for total weight:

- "Gold": 0,622 kg/m²
- "Abranet": 0,797 kg/m²

The weight of one disc is calculated as follows. The Table 4 above demonstrates that the coated abrasive jumbo roll has a width of 1460 mm or 1,46 m and that a number of 60 discs can be produced out of 1 m jumbo roll. With the help of this information the team first calculated the weight for 1,46 m² (1,46m*1m), which can be found in Table 5. Due to the geometrical shape of the disc, converting waste is generated during the cutting process (see Figure 8). Therefore, the weight of this waste needs to be subtracted from the weight of the 1,46 m² of coated abrasive jumbo roll.

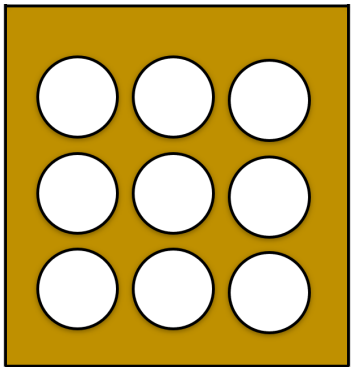


Figure 8: Waste due to the cutting process (Source: Mirka)

To calculate the weight of the geometrical waste[2], the information from Mirka was used that the converting waste is 25%. To calculate the weight of the discs, the weight of the waste was subtracted from the weight of 1,46 m². Since 60 discs can be produced out of 1,46 m², the weight for one disc was calculated (see Table 5) In order to simplify, the small holes inside of the disc were not subtracted.

	"Gold"	**"Abranet"**
Weight for 1 m²	0.622 kg	0.797 kg
Weight for 1,46 m² jumbo	0.908 kg	1.164 kg
Weight of geometrical waste[2] from 1,46 m²	0.227 kg	0.291 kg
Weight for 60 discs (holes not subtracted)	0.681 kg	0.873 kg
Weight for 1 disc (holes not subtracted)	0.0113469375 kg	0.01454525 kg

Table 5: Calculation of weight (own table)

[2] geometrical waste = the waste due to the gaps between the discs

The next step is to calculate the surface area of the sanding discs, which is shown in Table 6. The diameter of the discs was provided by Mirka (see Table 4 above). To calculate the surface area of “Gold”, the holes need to be subtracted. Since Mirka produces different dimensions of the product “Gold”, the team decided to use the product “150mm Grip 7H” for the calculation (see Figure 9 below). There is one large hole in the middle, which is used to attach the paper to the machine and six small holes to absorb dust. The product “Abranet” does not have any holes.

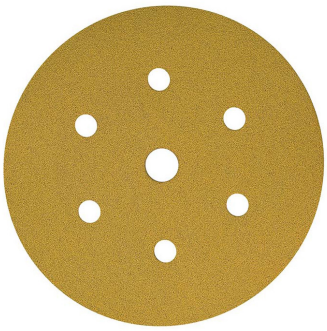


Figure 9: Product “Gold 150mm Grip 7H” (Source: https://www.krueckemeyer.de/fileadmin/Redaktuere/Produkte/Mirka/23628_002.jpg)

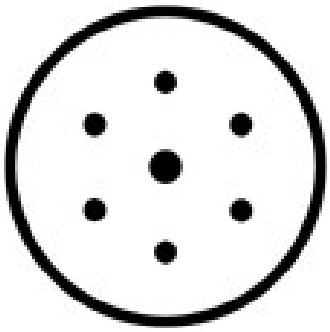


Figure 10: Product “Gold 150mm Grip 7H” (Source: https://www.mirka.com/sv/GOLD-230/)

Since the team got some waste from the holes from Mirka, the diameters of the holes were measured.

The size of the holes is calculated by the following formula:

$$size\ for\ small\ holes = 6 * pi * radius$$

$$size\ big\ hole = pi * radius$$

The surface area of one disc is calculated by the following formula:

$$surface\ area = pi * radius - size\ small\ hole - size\ big\ hole$$

	Discs “Abranet”	**Disc “Gold”**	**Small hole**	**Large hole**
Diameter in m	0.1500	0.1500	0.0090	0.0150
Radius in m	0.0750	0.0750	0.0045	0.0075
Surface area of one disc in m²	0.0177	0.0171	0.0004	0.0002

Table 6: Calculation of surface area of 1 disc (own table)

In order to add the transportation in SimaPro, a new unit needs to be calculated: ton kilometre (tkm). One tkm means that one metric ton of freight is transported for one kilometre. It is calculated by multiplying the transportation distance with the weight of the freight. It is important to mention that the weight of the trailer, container and truck or ship are not included in the following calculations.

Since exact transport distances were not available, the team estimated the distances for the trucks and the ships with the locations provided by Mirka.

The annual production of “Gold” and “Abranet” was provided by Mirka in m². To calculate how many discs are shipped to the warehouses on an annual basis, the amount of produced pieces necessary. This is calculated as follows:

produced pieces per year = produced m² per year / size for one disc

To calculate the weight per year, the following formula is used:

*weight per year = produced pieces per year * weight per disc*

Since the distribution ratios between the different warehouses were not available, the team decided to assume that the products get distributed evenly over the ten warehouses.

shipping weight per warehouse = weight per year / 10

The calculation is shown in Table 7 and a table of all calculated values can be found in appendix E.

	Produced m² per year	**Produced pieces of discs per year**	**Weight per year in kg**	**Shipping weight per warehouse in kg**
“Abranet”	346000	19222222	279592	27959
“Gold”	1300000	76470588	867707	86771

Table 7: Calculation of shipping weights (own table)

Assumed values

In addition to the calculable values from above, the modelling required a considerable number of values of which the calculation was not possible due to unavailable information. For this reason, a large number of assumptions were made in order to achieve the goal of the project and to create a comprehensive simulation in SimaPro.

The assumed values for the weights can be found in appendix F.

2.3.3 Modelling with SimaPro

Modelling

Once the goal and scope of the project are clearly defined and the inventory of the required in- and output is completed, the creation of the model can be initiated. The following is a step by step explanation on how to model with the SimaPro software.

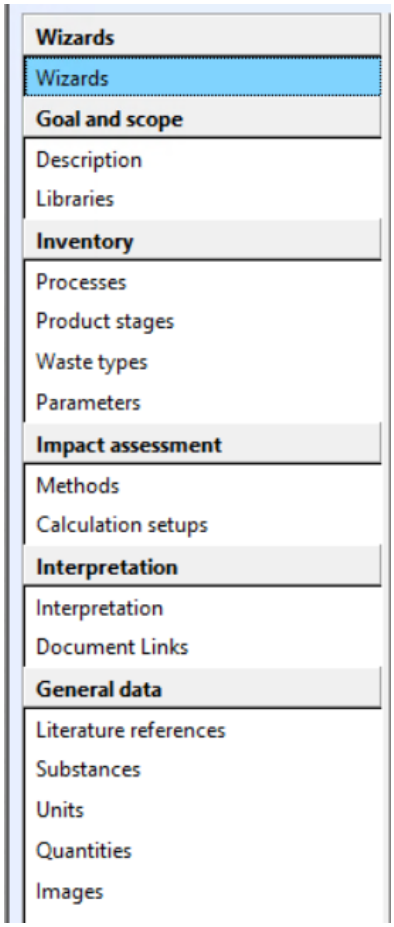


Figure 11: SimaPro, menu (Source: SimaPro)

When the program has been opened and a new project is created, the wizards menu will be shown on the left side of the screen. This is the principal menu and is used to navigate through the different options of the software.

Under “Goal and Scope”, the “Description” and “Libraries” can be found. The description is used to define the project in detail, based on following aspects: author, project goal, reason for the project, comments and project description. In “Libraries”, a list of all the available SimaPro databases will appear (see Figure 12). Depending on the project and the needed input, different databases can be chosen.

In this project, the library “Ecoinvent 3 – Allocation, default – system” has been selected. More information about the different SimaPro libraries can be found on the SimaPro website[3].

Selected	Name	Project manager	Protection
☐	Agri-footprint - economic allocation	Manager	
☐	Agri-footprint - gross energy allocation	Manager	
☐	Agri-footprint - mass allocation	Manager	
☐	BUWAL250	Manager	
☐	DK Input Output Database 99	Manager	
☑	Ecoinvent 3 - allocation, default - system	Manager	
☐	Ecoinvent 3 - allocation, default - unit	Manager	
☐	Ecoinvent 3 - allocation, recycled content - system	Manager	
☐	Ecoinvent 3 - allocation, recycled content - unit	Manager	
☐	Ecoinvent 3 - consequential - system	Manager	
☐	Ecoinvent 3 - consequential - unit	Manager	
☐	Ecoinvent system processes	Manager	
☐	Ecoinvent unit processes	Manager	

Figure 12: Selected library in SimaPro (Source: SimaPro)

After the project is described and the libraries are chosen, the actual modelling can begin. This will take place in the next section called “Inventory”, more specifically in “Processes”. Here, all production steps will be created and defined.

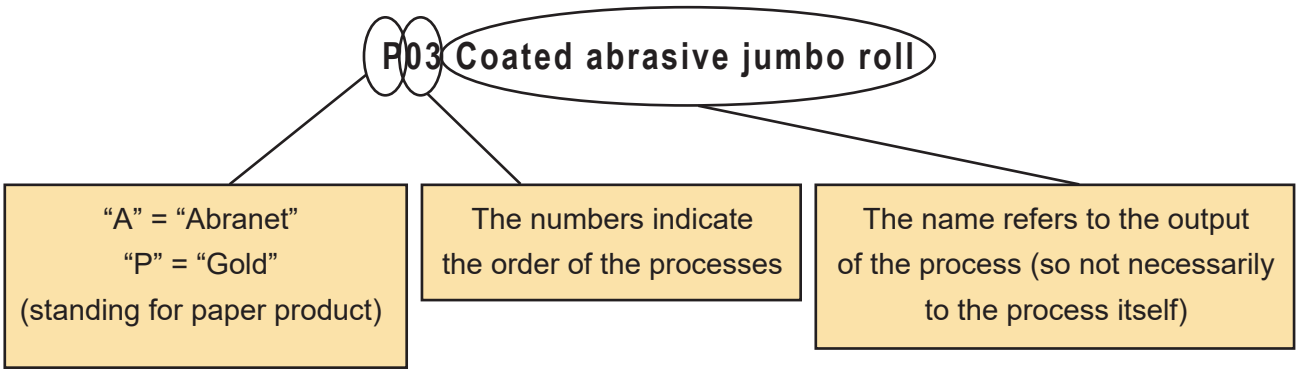
Since two different products will be analysed, two setups are needed (see Figure 13).

Name	Unit	Waste type	Project	Status
A01 Textile web	m2		LCA Mirka	None
A02 Impregnated textile jumbo	m2		LCA Mirka	None
A03 Post treated textile jumbo	m2		LCA Mirka	None
A04 Net jumbo roll	m2		LCA Mirka	None
A05 Cured net jumbo roll	m2		LCA Mirka	None
A06 Stearate coated net jumbo roll	m2		LCA Mirka	None
A07 Converted net discs	p		LCA Mirka	None
A07 Cutting waste	kg	Others	LCA Mirka	None
A08 Packaged net discs	p		LCA Mirka	None
A09 Shipped net discs	p		LCA Mirka	None
A09 Shipped net discs sea	p		LCA Mirka	None
P01 Paper jumbo roll	m2		LCA Mirka	None
P02 Latex coated jumbo roll	m2		LCA Mirka	None
P03 Coated abrasive jumbo roll	m2		LCA Mirka	None
P04 Cured coated abrasive jumbo roll	m2		LCA Mirka	None
P05 Cooled down cured coated abrasive jumbo roll	m2		LCA Mirka	None
P06 Flexed coated abrasive jumbo roll	m2		LCA Mirka	None
P07 Stearate coated abrasive jumbo roll	m2		LCA Mirka	None
P08 Final paper rolls	m2		LCA Mirka	None
P09 Converted discs	p		LCA Mirka	None
P09 Cutting waste (geometric)	g	Others	LCA Mirka	None
P10 Packaged discs	p		LCA Mirka	None
P11 Shipped discs	p		LCA Mirka	None
P11 Shipped discs sea	p		LCA Mirka	None

Figure 13: Created processes by the team (Source: SimaPro)

[3] https://simapro.com/databases/

In order to keep a clear overview, the processes are named as follows:



The processes have been created sequentially, this means that the output of the first process will be the input for the second one and successively. This methodology will allow the team to interconnect the processes without the need to assemble them.

To continue, Figure 14 displays an example of how one of the processes is created.

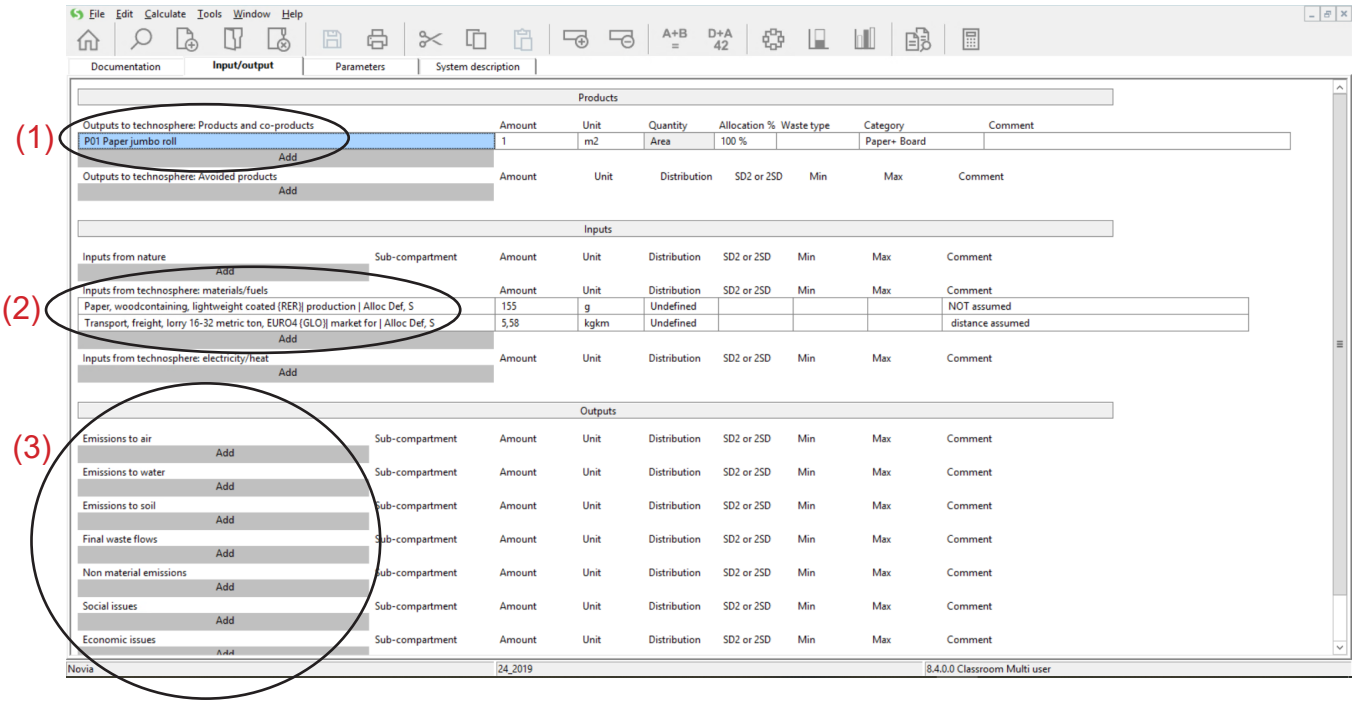


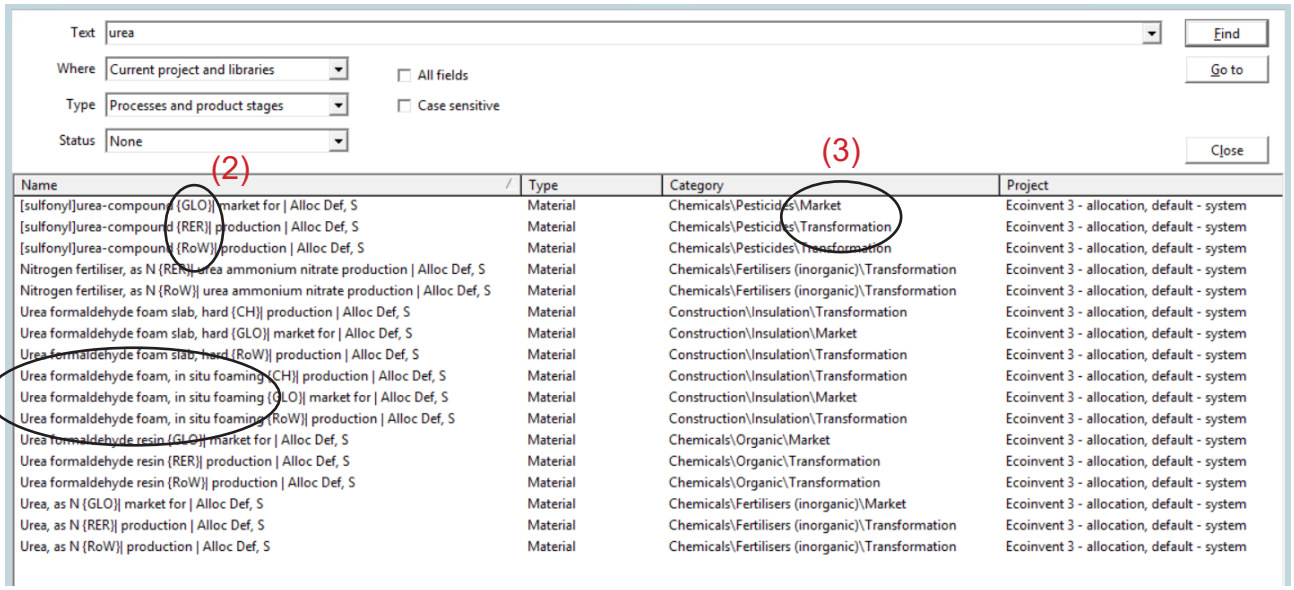
Figure 14: Example of input/output (Source: SimaPro)

In general, this is the first step in the life cycle for the product “Gold”. The process describes the transport of the paper that is used from the supplier to the factory. The first step in creating this process is to insert what output/products it will generate (1). The chosen unit and amount will depend on the functional unit, in this case, one square meter was chosen. The second step is to insert the input that is needed for this process (2). In this example, there are two inputs: paper and transport. It was provided by Mirka that one square meter of paper has a weight of 155 g, therefore grams was chosen as the unit for paper. In addition, the amount for the transport got calculated based on the amount of paper (155 g) and the distance between the supplier and the factory. More information about the unit and the calculations for transport can be found in chapter 2.3.2. In a third step, the output of emissions caused by this process would be added (3). In this example, since the inserted inputs (paper and transport) are standard processes in the SimaPro database, the emissions are already included in the process itself and therefore do not need to be added separately. Accordingly, no extra emissions are added.

To conclude, the process can be summarised as follows: in order to generate one square meter of a paper jumbo roll, 155 g of paper and 5.58 kgkm of transport are needed.

Materials

The SimaPro database provides thousands of different materials. As a result, for various materials it occurs that there are multiple/similar options available for the same material. Accordingly, in order for the LCA designer to be able to make a well-considered choice, the information about the materials used by the company has to be precise. As an example, Figure 15 shows the different options that were found when the team searched for the term “urea”.



Name	Type	Category	Project
[sulfonyl]urea-compound {GLO}| market for | Alloc Def, S	Material	Chemicals\Pesticides\Market	Ecoinvent 3 - allocation, default - system
[sulfonyl]urea-compound {RER}| production | Alloc Def, S	Material	Chemicals\Pesticides\Transformation	Ecoinvent 3 - allocation, default - system
[sulfonyl]urea-compound {RoW}| production | Alloc Def, S	Material	Chemicals\Pesticides\Transformation	Ecoinvent 3 - allocation, default - system
Nitrogen fertiliser, as N {RER}| urea ammonium nitrate production | Alloc Def, S	Material	Chemicals\Fertilisers (inorganic)\Transformation	Ecoinvent 3 - allocation, default - system
Nitrogen fertiliser, as N {RoW}| urea ammonium nitrate production | Alloc Def, S	Material	Chemicals\Fertilisers (inorganic)\Transformation	Ecoinvent 3 - allocation, default - system
Urea formaldehyde foam slab, hard {CH}| production | Alloc Def, S	Material	Construction\Insulation\Transformation	Ecoinvent 3 - allocation, default - system
Urea formaldehyde foam slab, hard {GLO}| market for | Alloc Def, S	Material	Construction\Insulation\Market	Ecoinvent 3 - allocation, default - system
Urea formaldehyde foam slab, hard {RoW}| production | Alloc Def, S	Material	Construction\Insulation\Transformation	Ecoinvent 3 - allocation, default - system
Urea formaldehyde foam, in situ foaming {CH}| production | Alloc Def, S	Material	Construction\Insulation\Transformation	Ecoinvent 3 - allocation, default - system
Urea formaldehyde foam, in situ foaming {GLO}| market for | Alloc Def, S	Material	Construction\Insulation\Market	Ecoinvent 3 - allocation, default - system
Urea formaldehyde foam, in situ foaming {RoW}| production | Alloc Def, S	Material	Construction\Insulation\Transformation	Ecoinvent 3 - allocation, default - system
Urea formaldehyde resin {GLO}| market for | Alloc Def, S	Material	Chemicals\Organic\Market	Ecoinvent 3 - allocation, default - system
Urea formaldehyde resin {RER}| production | Alloc Def, S	Material	Chemicals\Organic\Transformation	Ecoinvent 3 - allocation, default - system
Urea formaldehyde resin {RoW}| production | Alloc Def, S	Material	Chemicals\Organic\Transformation	Ecoinvent 3 - allocation, default - system
Urea, as N {GLO}| market for | Alloc Def, S	Material	Chemicals\Fertilisers (inorganic)\Market	Ecoinvent 3 - allocation, default - system
Urea, as N {RER}| production | Alloc Def, S	Material	Chemicals\Fertilisers (inorganic)\Transformation	Ecoinvent 3 - allocation, default - system
Urea, as N {RoW}| production | Alloc Def, S	Material	Chemicals\Fertilisers (inorganic)\Transformation	Ecoinvent 3 - allocation, default - system

Figure 15: Example for a database in SimaPro (Source: SimaPro)

In this list, several characteristics of the materials can be identified:

(1) The detailed name of the material.

(2) An indication of the origin of the material. These are the most common ones:

“GLO” = global, an average valid for all countries in the world

“RER” = Europe

“RoW” = rest of the world, an exact copy of the “GLO” dataset with uncertainty adjusted. It is then linked with activities of a precise country or place, creating a specific supply chain.

(3) Market or transformation: the market section indicates that the materials are distributed globally and therefore are considered an average of the transport of the global market. This is used when the origin or type of transport is unknown. Otherwise, the materials found in the transformation section will be used, in which the transport has to be modelled manually and therefore generate a more accurate result.

Energy recovery

Mirka has a particularity, they cover a part of their energy consumption by burning their own waste and recovering the heat. More specific information can be found in chapter 2.3.2.

As an example, the energy recovery from the “Gold” production line can be seen in Figure 16. To add this type of energy recovery in SimaPro, the “Output to technosphere: Avoided products” (1) section will be used. By doing this, SimaPro will take into account that energy is recovered and will recalculate the impact of the energy consumption.

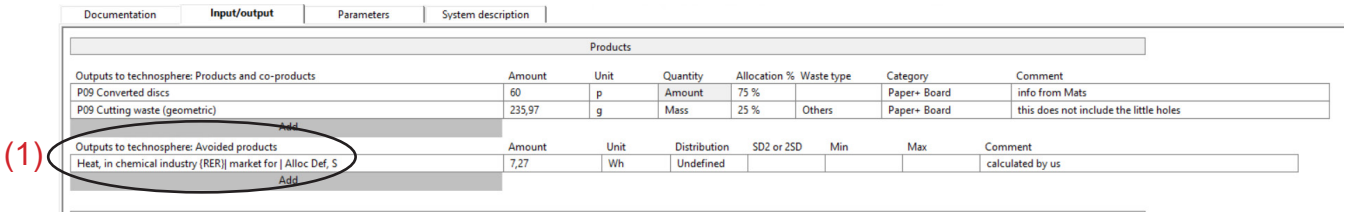


Figure 16: Example for “Avoided products” Simapro (Source: SimaPro)

Impact assessment

When all the necessary processes have been created, the calculation of the results can be initiated. This part is called “impact assessment”. Here, a specific method has to be chosen and this choice will depend on the wanted output. More information about these methods can be found in chapter 2.2.2.

Initially, the ReCiPe 2016 Midpoint (H) and ReCiPe 2016 Endpoint (H) will be used since these are the default methods according to the descriptions in SimaPro.

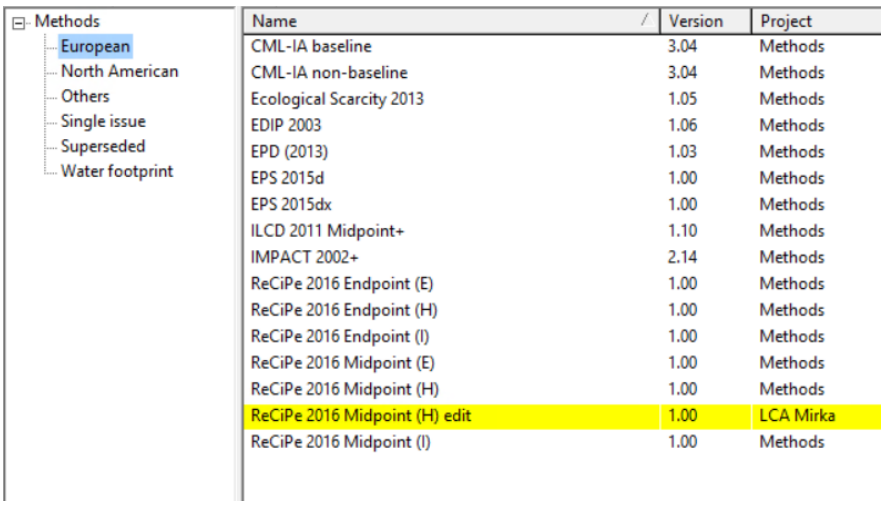
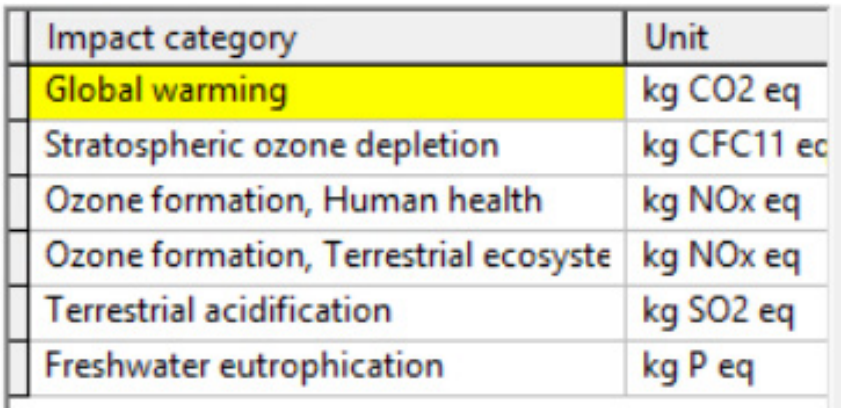


Figure 17: Methods in SimaPro (Source: SimaPro)

After looking into the midpoint method, the team decided that considering all 15 categories is not suitable. Therefore, a copy has been made of the ReCiPe 2016 Midpoint (H) and only the categories that have been considered important for the project have been selected (see Figure 18).



Impact category	Unit
Global warming	kg CO2 eq
Stratospheric ozone depletion	kg CFC11 ec
Ozone formation, Human health	kg NOx eq
Ozone formation, Terrestrial ecosyste	kg NOx eq
Terrestrial acidification	kg SO2 eq
Freshwater eutrophication	kg P eq

Figure 18: Selected impact categories by the team (Source: SimaPro)

2.4 Results and interpretation

In the previous chapters the materials and methods were explained. Now the results produced by SimaPro are presented and interpreted. For this purpose, two different comparisons are carried out: a comparison of the products “Gold” and “Abranet” as well as a comparison of the transport by sea and by air. Currently the products are transported to China and India by air. Since the team suspected that the emissions could be reduced by transporting the goods by sea, a second scenario was created. The team changed the transport route from air to sea in order to examine the effects on the LCA. The results are explained in chapter 2.4.2 and 2.4.3. But first the network will be explained using an example. The networks for the other scenarios can be found in appendix G.

2.4.1 Network

For illustration purposes, the network for the product “Gold” is demonstrated in the following. SimaPro can display the network in relation to each impact category. As an example the team selected the category “global warming”, which is why all values are displayed in CO_2-equivalents. Since the FU in this project was defined as 1000 pieces, the network is modelled for this quantity of sanding discs.

Such a network shows all processes, which were entered in SimaPro: the production processes as well as all added transports, energy consumptions and emissions. At the top of each box the quantity of the respective output is displayed. Since 1000 sanding discs are produced in total, all quantities are related to the 1000 pieces. Furthermore, the name of the processes (output) is displayed as well as the CO_2-equivalents. The percentage of impact is visualised by the width of the arrows.

Figure 19 shows the top part of the network. The total impact on global warming of 1000 shipped discs is 49 kg CO_2-equivalents. Furthermore, the network shows the impact on global warming of each process. The larger the arrow, the higher the contribution to the total impact. The production of the discs has the highest impact on global warming, while the transport shows a lower impact. In appendix G the remaining parts of this network are displayed.

The appendix G also presents the networks for the products “Gold” (P) and “Abranet” (A), both for transportation by sea and by air.

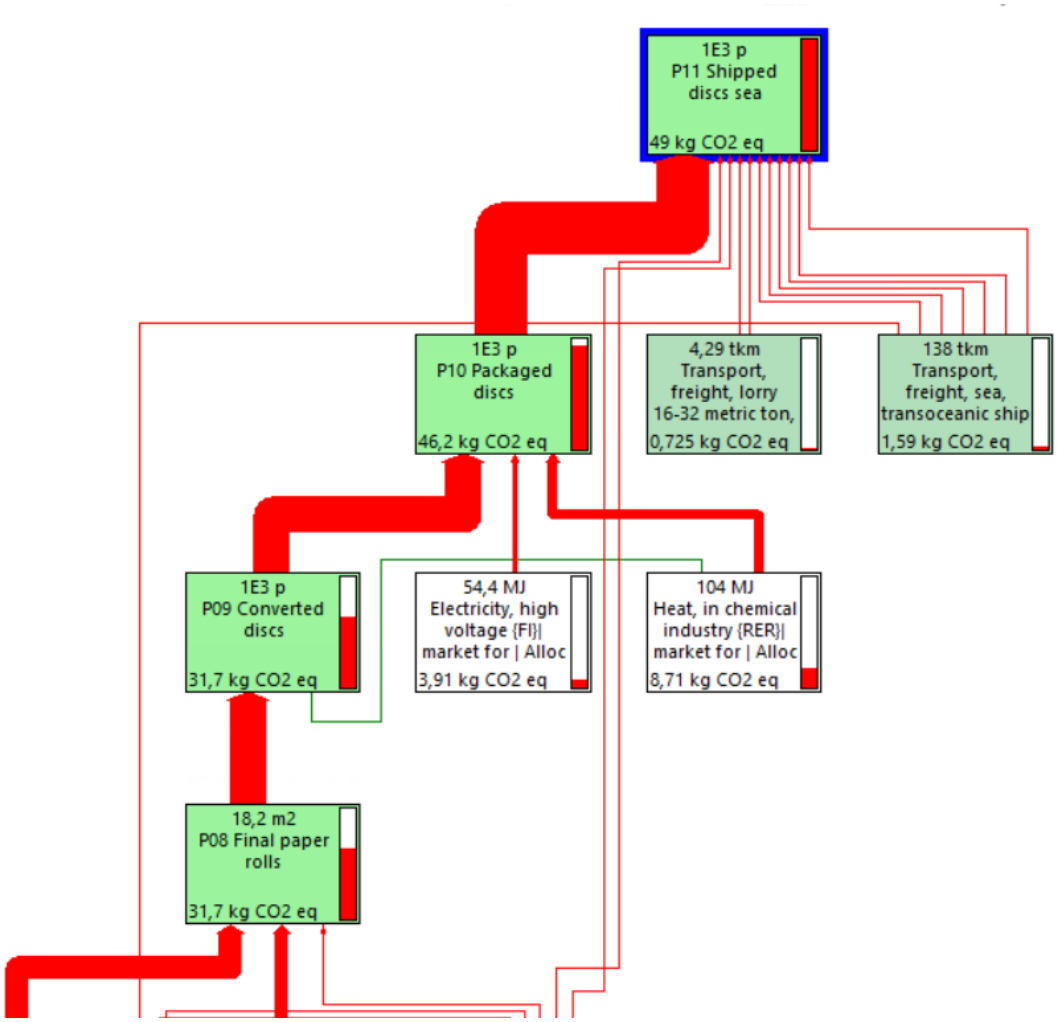


Figure 19: Example for network, product "Gold" (Source: SimaPro)

2.4.2 Comparison midpoint

In this part, “Gold” and “Abranet” get compared. To entirely understand what the following charts represent, more explanation is needed. When SimaPro calculations are plotted in a chart, the outcome will look similar to the chart in Figure 20. One can note that all “own figures” is this chapter are based on the real SimaPro results which can be found in appendix H.

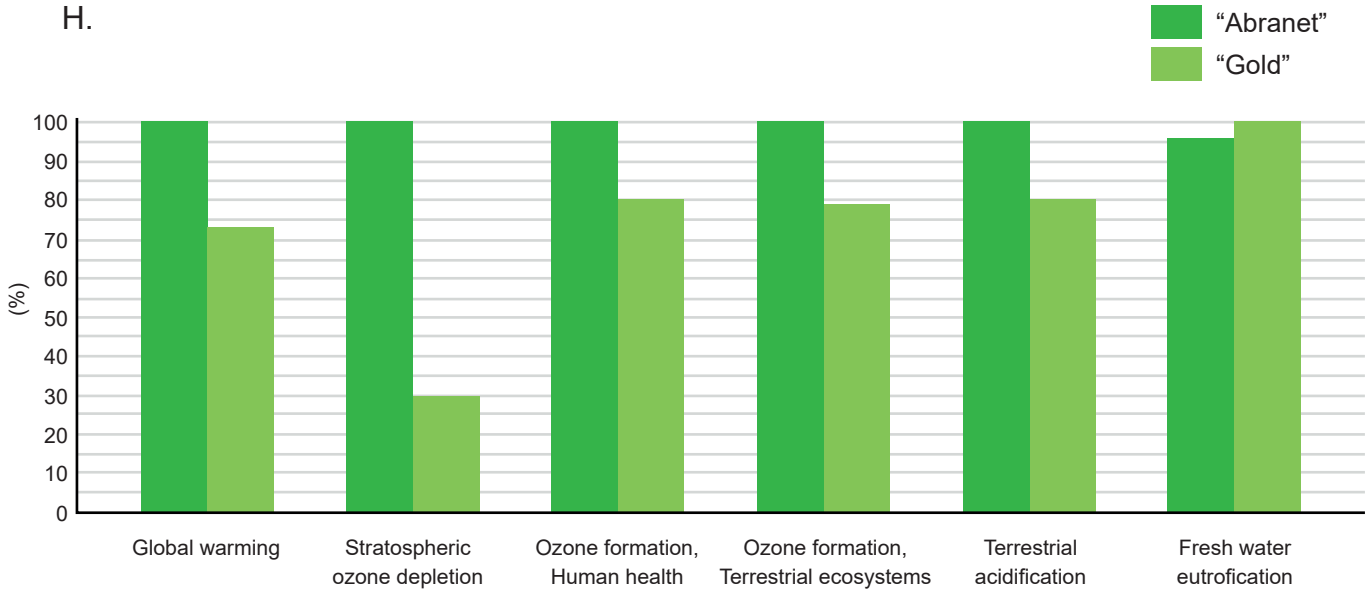


Figure 20: Midpoint comparison “Abranet” - “Gold”
(own figure, Source: SimaPro)

On the x axis, the different categories are displayed. Those categories stand on their own, this means that in this chart they are not related to each other in any way.

On the y axis, the unit used is percentage (%). To clarify what this indicates, for now, only the category “Global warming” will be examined. As shown in Figure 21, the products “Gold” and “Abranet” do not have the same value for impact on global warming.

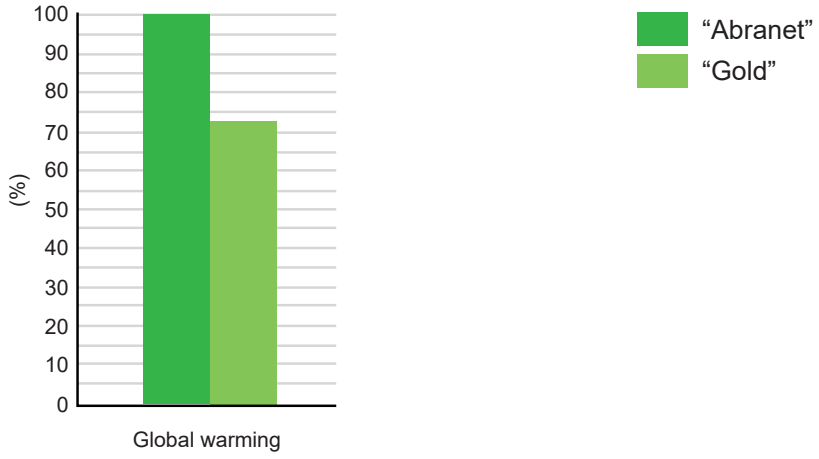


Figure 21: Midpoint comparison “Abranet” - “Gold”, Global warming
(own figure, Source: SimaPro)

Therefore, SimaPro selects the highest of both values (which in this case is the value of Abranet) and plots it as 100% on the chart. After that, all the other values (in this case the value for “Gold”) get plotted in relation to the highest value. For example: if the value for “Abranet” would be 200 and for “Gold” 150, the value for “Abranet” will be plotted as 100% and for “Gold” as 75%.

In conclusion, these charts only visualise how big the differences are between the analysed subjects, for example: it is impossible to determine if these values are high or low based on this chart. SimaPro is not able to plot the chart in any other way.

Therefore, to be capable of comprehending the results better, both products will be compared with a third process. This will be a process that takes place in everyday life and is relatively easy to relate to. In this case, the process “driving a car for 100 kilometres” was selected. It is important to understand that this additional process stands on its own and has no relation to the two products. It is only added as a reference to comprehend the results.

In the following chart, “Gold” and “Abranet” are compared using the ReCiPe 2016 Midpoint H method. As said before, to make the results more comprehendible, as a reference, a passenger car that drives for 100 km is added. Note that these are the results of producing 1000 discs and that the actual annual production lays way higher.

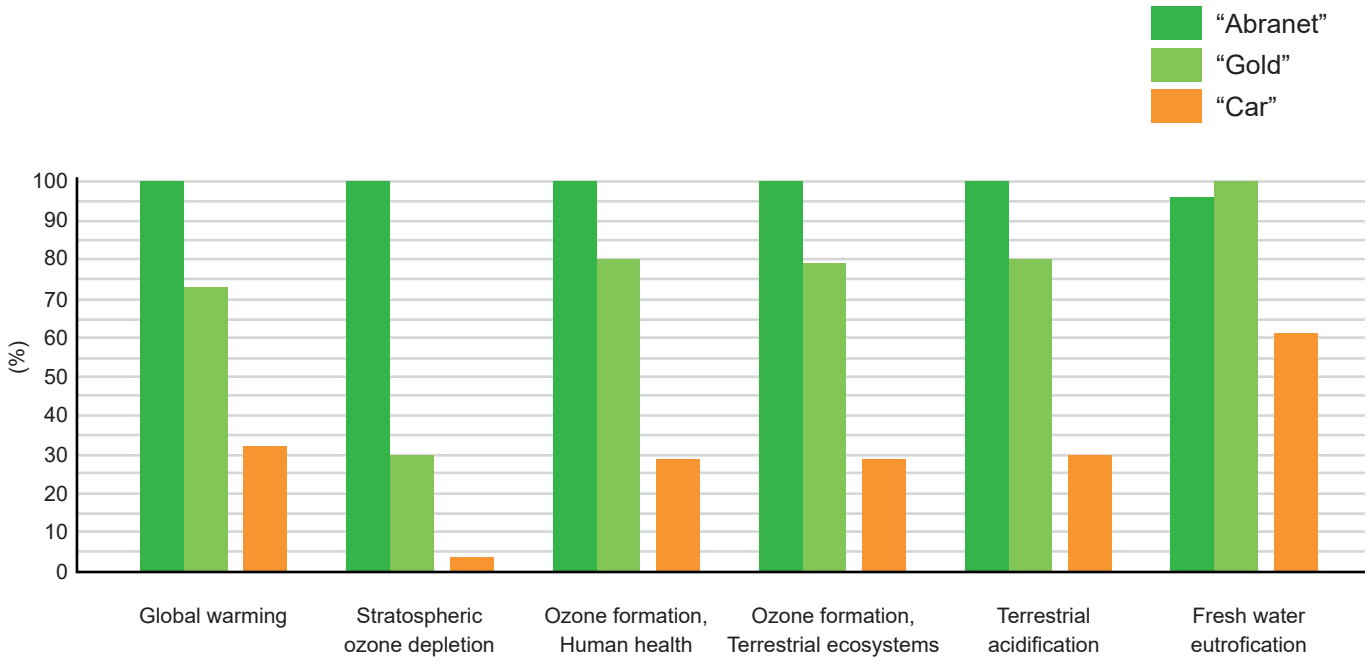


Figure 22: Midpoint comparison “Abranet” - “Gold” - “Car”
(own figure, Source: SimaPro)

As displayed in the chart above, “Gold” has an overall lower impact compared to “Abranet”. Only for freshwater eutrophication, “Abranet” has a slightly lower influence. Compared to the car, both products have considerably more impact. Of course, these differences are relative.
More information about the six categories can be found in chapter 2.2.3.

To give the previous chart more perspective, in Figure 23 the exact values are displayed. The overall values are very low and therefore the differences are not that big.

Impact category	Unit	A09 Shipped net discs	P11 Shipped discs	Transport, passenger car
Global warming	kg CO2 eq	100	72,7	32,2
Stratospheric ozone depletion	kg CFC11 eq	0,000442	0,000131	1,58E-5
Ozone formation, Human health	kg NOx eq	0,263	0,21	0,0751
Ozone formation, Terrestrial ecos	kg NOx eq	0,274	0,217	0,0784
Terrestrial acidification	kg SO2 eq	0,297	0,237	0,0888
Freshwater eutrophication	kg P eq	0,01	0,0105	0,00641

Figure 23: Midpoint comparison “Abranet” - “Gold” - “Car”, values (Source: SimaPro)

The following is a suggestion made by the team. Since the results from the networks indicate that the contribution from the aircrafts used for shipping to the warehouses in India and China are rather high, in a second scenario, a sea freight was chosen instead. Although the distance is considerably longer compared to the distance from the aircraft, Figure 24 and Figure 25 learn that for both “Gold” and “Abranet” the option for the sea freight has less impact than the one with the airplane. In conclusion, the sea freight option could be taken into consideration by the company as a possible alternative.

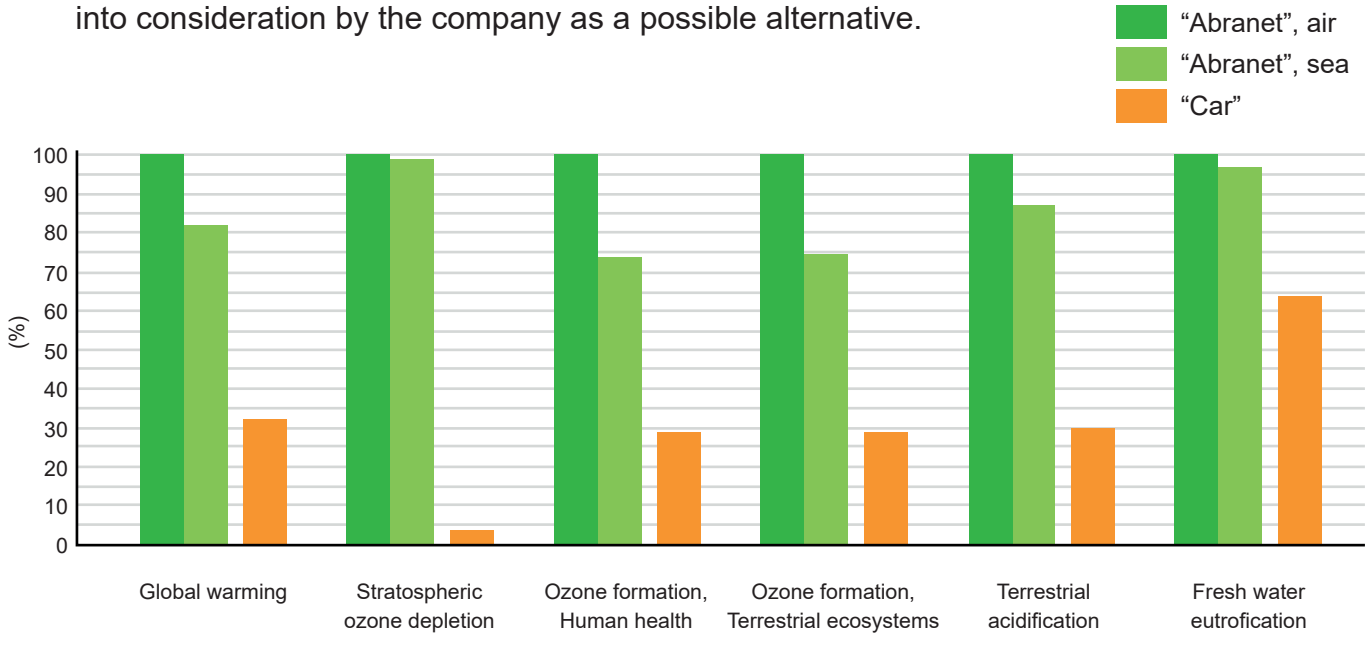


Figure 24: Midpoint comparison “Abranet”, air - sea (own figure, Source: SimaPro)

Impact category	Unit	A09 Shipped net discs	A09 Shipped net discs sea	Transport, passenger car
Global warming	kg CO2 eq	100	82,4	32,2
Stratospheric ozone depletion	kg CFC11 eq	0,000442	0,000436	1,58E-5
Ozone formation, Human health	kg NOx eq	0,263	0,194	0,0751
Ozone formation, Terrestrial ecos	kg NOx eq	0,274	0,203	0,0784
Terrestrial acidification	kg SO2 eq	0,297	0,257	0,0888
Freshwater eutrophication	kg P eq	0,01	0,00969	0,00641

Figure 25: Midpoint comparison "Abranet", air - sea, values
(Source: SimaPro)

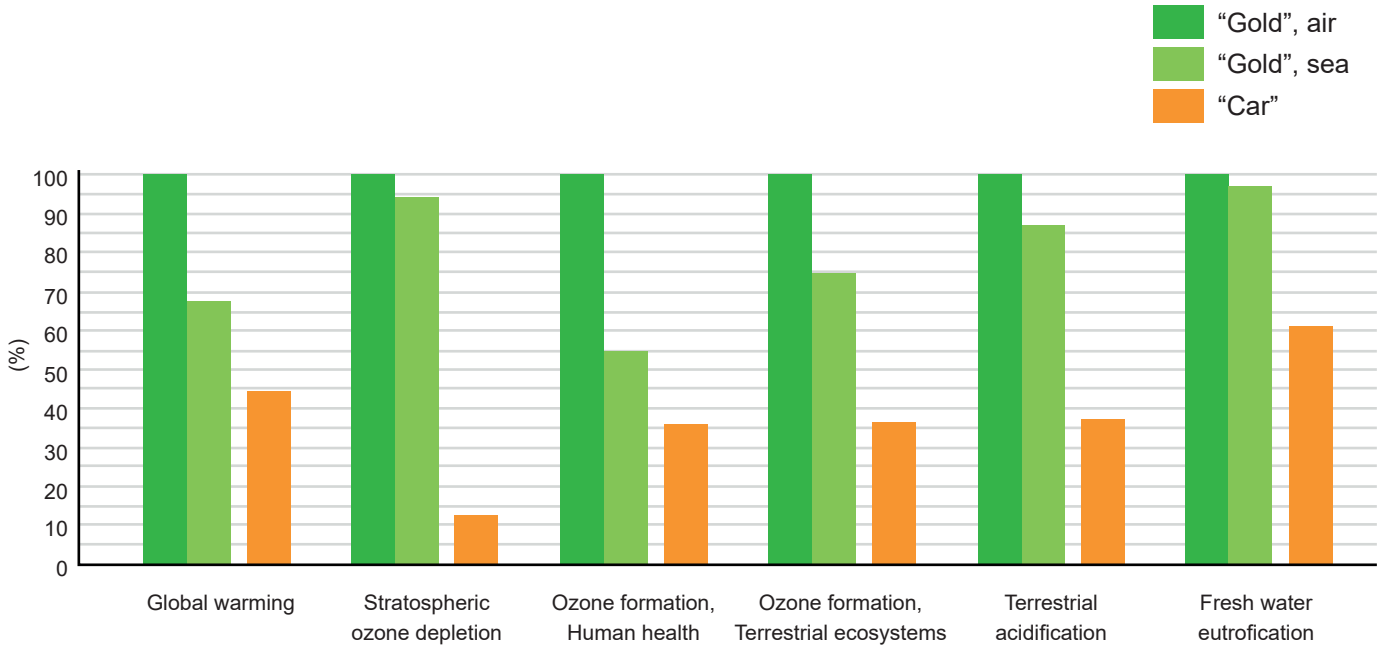


Figure 26: Midpoint comparison "Gold", air - sea
(own figure, Source: SimaPro)

Impact category	Unit	P11 Shipped discs	P11 Shipped discs sea	Transport, passenger car
Global warming	kg CO2 eq	72,7	49	32,2
Stratospheric ozone depletion	kg CFC11 eq	0,000131	0,000123	1,58E-5
Ozone formation, Human health	kg NOx eq	0,21	0,114	0,0751
Ozone formation, Terrestrial ecos	kg NOx eq	0,217	0,119	0,0784
Terrestrial acidification	kg SO2 eq	0,237	0,179	0,0888
Freshwater eutrophication	kg P eq	0,0105	0,0102	0,00641

Figure 27: Midpoint comparison "Gold", air - sea, values
(Source: SimaPro)

2.4.3 Comparison endpoint

In this part, “Gold” and “Abranet” are compared using the ReCiPe 2016 Endpoint H method. This means that the different categories from midpoint will be put together into three new categories: human health, ecosystems and resources. More information about this can be found in chapter 2.2.3.

To make the results more comprehendible, as a reference, a passenger car that drives for 100 km is added. Note that this is the result of producing 1000 discs and that the actual annual production lays way higher.

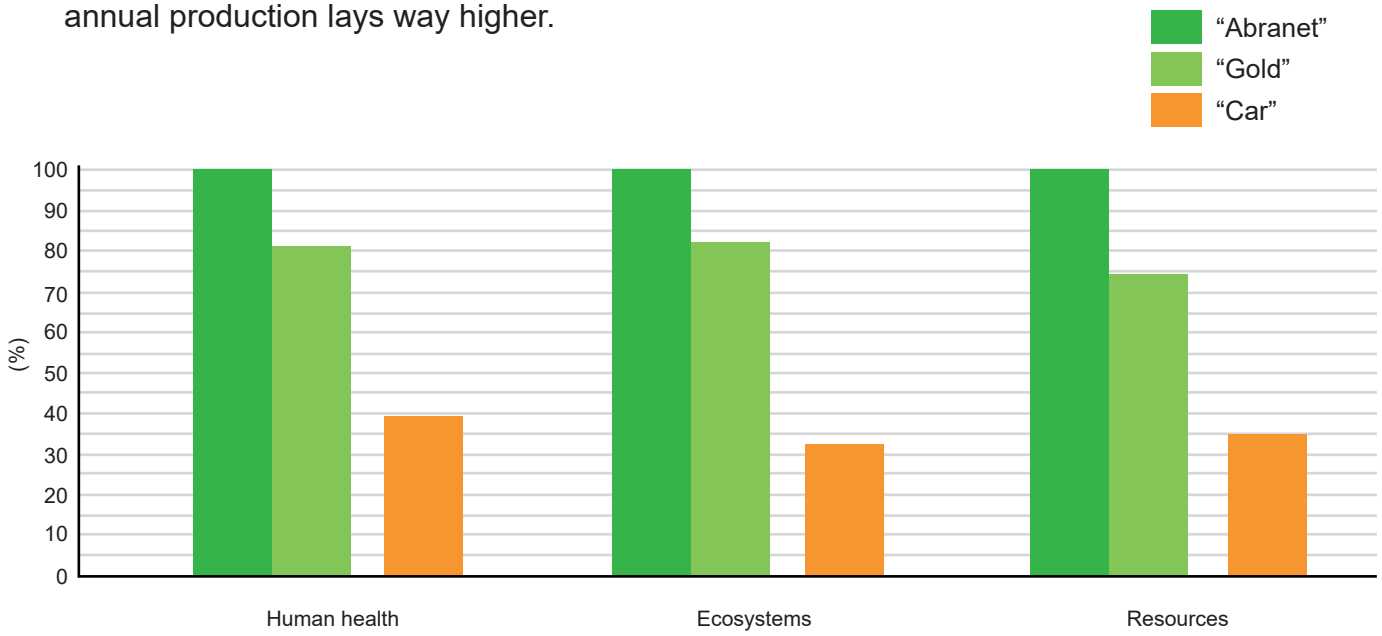


Figure 28: Endpoint comparison “Abranet” - “Gold” - “Car”
(own figure, Source: SimaPro)

As already indicated in the results of the midpoint method, also here it is noticed that “Gold” has less impact than “Abranet” on all aspects.

To give more perspective, in Figure 29 the exact values are displayed.

Damage category	Unit	A09 Shipped net discs	P11 Shipped discs	Transport, passenger car
Human health	DALY	0,000158	0,000129	6,22E-5
Ecosystems	species.yr	4,17E-7	3,43E-7	1,36E-7
Resources	USD2013	11,9	8,88	4,19

Figure 29: Endpoint comparison “Abranet” - “Gold” - “Car”, values
(Source: SimaPro)

Also here, the sea fright suggestion is added and shows similar results as in the previous comparison (see Figure 30 and Figure 32). In Figure 31 and Figure 33 the exact values are displayed.

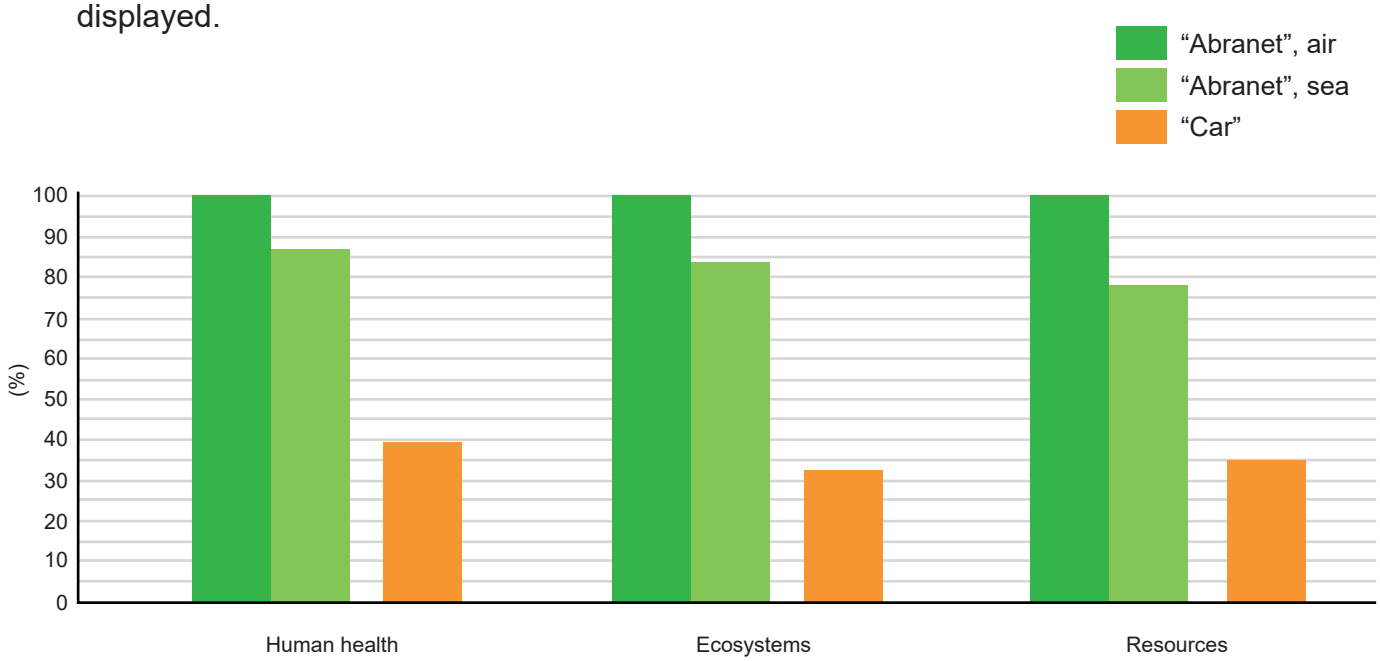


Figure 30: Endpoint comparison "Abranet", air - sea
(own figure, Source: SimaPro)

Damage category	Unit	A09 Shipped net discs	A09 Shipped net discs sea	Transport, passenger car
Human health	DALY	0,000158	0,000137	6,22E-5
Ecosystems	species.yr	4,17E-7	3,48E-7	1,36E-7
Resources	USD2013	11,9	9,26	4,19

Figure 31: Endpoint comparison "Abranet", air - sea, values
(Source: SimaPro)

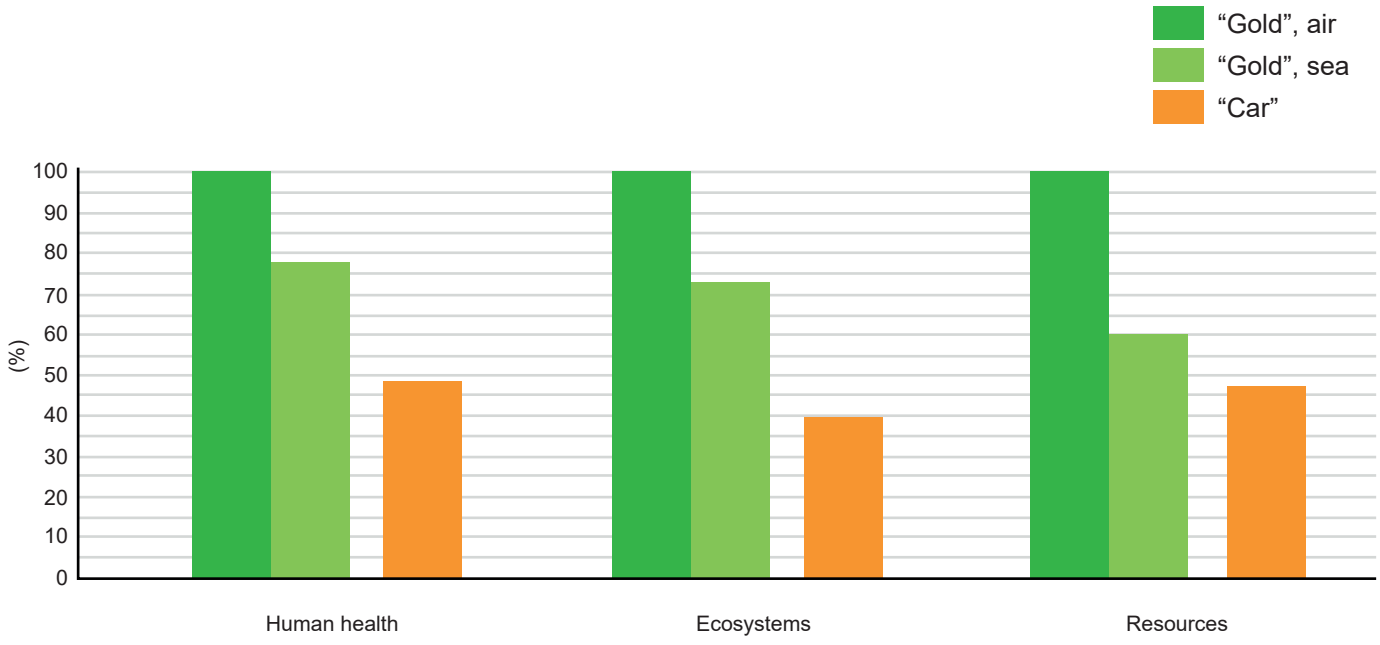


Figure 32: Endpoint comparison "Gold", air - sea
(own figure, Source: SimaPro)

Damage category	Unit	P11 Shipped discs	P11 Shipped discs sea	Transport, passenger car
Human health	DALY	0,000129	0,0001	6,22E-5
Ecosystems	species.yr	3,43E-7	2,5E-7	1,36E-7
Resources	USD2013	8,88	5,35	4,19

Figure 33: Endpoint comparison "Gold", air - sea, values
(Source: SimaPro)

2.5 Conclusion and suggestions

The main part of the project focused on an LCA, especially on the functionality of the SimaPro software and a realisation of an LCA for two products from Mirka. The data collection was a significant element in this process. The software requires a considerable amount of detailed information as input, which was not all collected in the limited period of time. Therefore a large number of calculations and assumptions were conducted, which were documented and can be changed and updated by the company in the future. SimaPro delivers a large amount of results, from which a number of relevant ones have been selected. No comprehensive presentation of all available results was carried out, since it was not the main goal of the company to receive detailed results.

In order to demonstrate which conclusions can be drawn by using the software, the team carried out a comparison of the products "Gold" and "Abranet". The comparison indicated that the product "Gold" has a lower impact on global warming than "Abranet", apart from freshwater eutrophication, where Abranet has a lower impact.

Furthermore, the results indicated that transport to China and India by air has a significant impact on the environment, thus the effect of transporting by sea was tested. This experiment confirmed the assumption that the environmental impact decreases by using the sea route. For this reason the team recommends to change the route from air to sea, in order to reduce the environmental impact.

In conclusion, modeling in SimaPro requires a large amount of detailed information for each process, especially concerning energy consumptions and emissions. To produce a well-structured result, the values for each individual process are required, but this causes considerable costs, for example when installing new meters. Consequently this issue, including economic considerations, needs to be analysed separately and was not part of this project.

This report provides an overview of creating an LCA with SimaPro. For more detailed explanations and instructions the tutorial provided by SimaPro is recommended[3].

[3] https://www.pre-sustainability.com/download/SimaPro8Tutorial.pdf

3. Usage of the waste

3.1 Introduction

Over the past two years, climate change and environmental impact are issues that are making headlines almost on a daily basis. People, organisations and companies became more critical when it comes to these subjects. One of the main contributors to these issues is waste. In the modern world, people have become more aware about the amount of waste they produce and what impact this has on the environment.

Therefore, overall awareness has increased, different ways and possibilities to deal with this waste are taken into consideration and companies are constantly trying to make their business more sustainable. One of those companies is Mirka. As one of the world leaders in surface finishing technology, Mirka has shown its interest in improving their waste management in order to contribute to a cleaner environment.

3.2 Secondary scope of the project

The secondary target of the EPS project is about the usage of waste. The production of sanding discs generates in total 3 905 550 kg waste per year. Due to the round geometry of the discs, gaps will be left during the cutting process (see Figure 34).

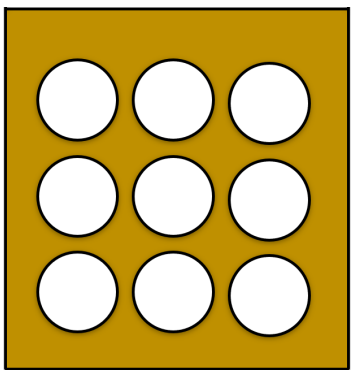


Figure 34: Waste due to the cutting process (Source: Mirka)

In addition, extra waste is produced during the production process of the standard product “Gold”, because there need to be holes in the discs (see Figure 35). These holes are necessary to remove the dust during the sanding process later.

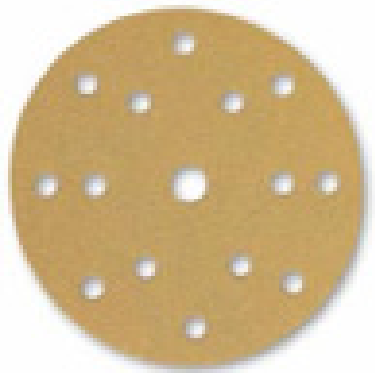


Figure 35: Waste from the holes (Source Mirka)

Currently, the waste from these processes is burned. The EPS team will investigate possible usages for this waste and find business ideas. Within the scope of this task, possibilities for material recovery processes are to be found.

3.3 Materials and methods

3.3.1 Research

In order to get an overview of the possibilities that already exist, the team did some research first. The research showed that there are only a few ideas.

Students from RWTH Aachen University (Germany) carried out a project called “Recycling of Coated Abrasives – ReCAb” together with the company PDR Recycling GmbH. The students developed a process for recovering the abrasive grains.

First the abrasives are preconditioned, which means that the abrasives are shredded. In a thermal process the grains and the binder are separated. In this process the organic binders and bases are removed, and the inorganic part is left as a powder, which includes the abrasive grains. The next step is called deagglomeration and is a “careful separation of the abrasive grain-ash agglomerates”. After that, the abrasive grains are separated from

the other materials, which are for example residual waste or minerals. Finally, the abrasive grains are classified in order to get grain classes that conform to standards. (PDR) (Giani)

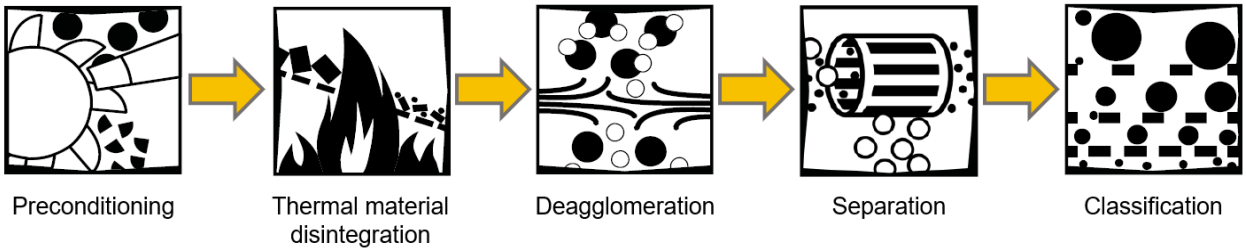


Figure 36: Recycling steps (Adapted from: Schenke)

Advantages / benefits

This method of recovering abrasive grit has both ecological and economic advantages. From an environmental point of view, it has the benefit that the materials can be recycled, which is a more sustainable solution than burning. The primary energy consumption as well as the CO_2 emissions can also be reduced.

On the economic side, disposal costs are lower than those of burning. Furthermore, the purchase price of recycled grains is lower than the original price. Furthermore, a “closed loop circulation of self-developed, high-quality abrasive grains” can be created in the company. (PDR)

For the full report and a detailed explanation, please see the final report of the project from RWTH Aachen. (Giani)

3.3.2 Brainstorm

Since the topic was rather new to the team, in order to get started, several brainstorm sessions were organized. This methodology allows to explore different points of view and come up with alternative solutions. The following list shows the various possibilities that have been found.

• Burning

This was the first thought, to burn the waste and recover the heat to use it again in the factory. Since Mirka is already using this method, the team has not delved much into this possibility.

General ideas:

• Decoration

Since the sanding paper has different colours and sizes, the possibility came into mind to use the waste to create art. For example: postcards, or use it as a painting canvas.

• Chemical decomposition

Instead of reusing the waste, the team thought of a way to create a chemical reaction that decomposes the sanding paper into its original components. As a result, Mirka would be able to recover these raw materials and use them again in the production line. Since the team had no expertise in this field to explore this further, additional research has been done and can be found in chapter 3.3.1.

• Create new sand paper

The shape of the circles is rather small, therefore it might be possible to create a new sanding paper surface by ‘gluing’ several circles together. The quality of this new paper will probably have decreased compared to the original one, but it could still be sold as a less quality product for those who do not desire a professional result. This option still needs to be tested.

Ideas according “grip”:

• Jar opener

Usually, the content of a jar is well protected and kept fresh by a secure lid. Therefore it can occur that opening the lid for the first time is not that easy. A possible solution for this problem could be to use sanding paper, by placing it on the jar and squeezing it while turning. Thanks to the extra grip of the sanding paper, the jar can easily be opened.

• Shoe sole

To prevent people from falling on slippery areas/surfaces, sanding paper can be glued onto the shoe sole in order to obtain more grip and to reduce the chance of falling. An earlier thought was to stick the sanding paper on the surface itself, but this would only be suitable for relatively small areas.

• Flowerpot

It's not uncommon that small animals like slugs or snails climb plants and deteriorate them. To avoid this, pieces of sanding paper can be placed around or inside the pot. This will avoid the ability for the slugs to climb the pot because of its rough surface. Your plants have never been this safe!

According to the last three ideas, in a perfect scenario, a commercial relationship with a company that manufactures these items would be established in order to implement these "upgrades" during the production process.

All the ideas are focussed on providing Mirka several possibilities to reuse the waste material from their production process in such a way that they can sell it at a low price without the need to worry about it. When the trade agreements are arranged with the companies responsible for the manufacturing of these products, these ideas could transform into long-term solutions.

3.4 Results and conclusion

Mirka is a company that is aware of its waste and tries to handle it to the best of their ability, keeping an eye on the environmental impact while doing so. This is why they want to investigate new approaches to find better ways to deal with this waste and explore the options for possible reuse.

The team used two methods to approach this problem: research and brainstorming.
For the research, already existing methods of dealing with waste have been examined. The found idea is a method where the grains of the sanding disc can be recovered. This is a process Mirka is familiar with since they are already using a similar method themselves for handling the waste.

For the brainstorm, several possible solutions have been listed and explained. These solutions are mainly low scale solutions, which means that they will not cover the total amount of waste on their own. Therefore, several options could be combined to create a wider range of usages. In order to evaluate which solutions are suitable, further research is needed.

In conclusion, there are several options when it comes to reusing the waste which can be examined further. After that, possible business plans can be created and productive cooperations with other companies could occur, which is positive both for the company and for the environment.

4. Conclusion and suggestions

4.1 Conclusion

In this project the EPS team worked in cooperation with Mirka and focused on two issues for which the company required a solution.

The primary target was the creation of an LCA with the focus on the functionality of the software SimaPro. The team was assigned to create an LCA for the products “Gold” and “Abranet” to demonstrate which conclusions can be drawn by using the software.

One key lesson was that collecting data at the beginning is one of the major steps. The software requires a considerable amount of detailed information as input, which was not all collected in the limited period of time. Therefore a large number of calculations and assumptions were conducted, which were documented and can be changed and updated by the company in the future. SimaPro delivers a large amount of results, from which a number of relevant ones have been selected for interpretation. No comprehensive presentation of all available results was carried out, since it was not the main goal of the company to receive detailed results. In conclusion it can be seen that, according to the categories considered, the production of “Gold” has a lower environmental impact than the production of “Abranet”. Only in the categorie freshwater eutrophication, the product “Abranet” has a lower impact.

Since Mirka attaches high value to sustainable production, a secondary aim of the project was to investigate new solutions for reusing the large amount of waste produced during the production process. For this purpose the team applied two separate methods: research and brainstorming. As a result of the research a suitable solution was found for the recycling of coated abrasives from RWTH Aachen University. Students developed a method to separate the grains for reusing. In addition, the various approaches that the team elaborated themselves can provide a basis for business ideas in the future.

4.2 Suggestion

Finally, the team can recommend the software SimaPro to the company. In the beginning it requires time to comprehend the software, but it has a large amount of functions that allow a comprehensive and detailed creation of an LCA. SimaPro automatically generates a large number of results, which subsequently can be interpreted. This report provides an overview of creating an LCA with the software. For more detailed explanations and instructions the tutorial provided by SimaPro is recommended.

In conclusion, modeling in SimaPro requires a large amount of detailed information for each process, especially concerning energy consumptions and emissions. To produce a well-structured result, the values for each individual process are required, but this causes considerable costs, for example when installing new meters. Consequently this issue, including economic considerations, needs to be analysed separately and was not part of this project.

Furthermore, the results indicated that transport to China and India by air has a significant impact on the environment. With the help of SimaPro, the team found out that the environmental impact decreases by using the sea route. For this reason the team recommends to change the route from air to sea, in order to reduce the environmental impact.

5. References

Álvarez, V.: 6 *usos del papel de lija que desconocias.* [Online]. Available from: https://www.vix.com/es/imj/hogar/6401/6-usos-del-papel-de-lija-que-desconocias [Accessed 22.04.2020]

DIN Deutsches Institut für Normung e.V.: *Environmental management – Life cycle assessment – Principles and framework (ISO 14040:2006).* German and English version EN ISO 14040:2006. 2009. Berlin

DIN Deutsches Institut für Normung e.V.: *Environmental management – Life cycle assessment – Requirements and guidelines (ISO 14044:2006 + Amd 1:2017).* German version EN ISO 14044:2006 + A1:2018. 2018. Berlin

ESU-services Ltd.: *Description of life cycle impact assessment methods. Supplementary information for tenders.* [Online] 2020. Available from: http://www.esu-services.ch/fileadmin/download/tender/ESU-Description-of-LCIAmethods.pdf [Accessed 29.04.2020]

ETH Zürich: *Vorlesung: Grundzüge "Ökologische Systemanalyse". Methodik Ökobilanz. Wirkungsbilanz.* [Online] 2017. Available from: https://ethz.ch/content/dam/ethz/special-interest/baug/ifu/eco-systems-design-dam/documents/lectures/2017/Bachelor/OESA/LCA-4_Wirkungsbilanz%20Version%20Final.pdf [Accessed 25.04.2020]

European Project Semester: *About EPS.* [Online]. Available from: http://www.europeanprojectsemester.eu/concept [Accessed 20.02.2020]

Finnveden, G. et al.: *Recent developments in Life Cycle Assessment. Journal of Environmental Management.* [Online] 2009. 91 (1-21). pp. 1-2. Available from: https://doi.org/10.1016/j.jenvman.2009.06.018 [Accessed 06.03.2020]

Gabriel, D. et al.: *Life cycle assessment of biofiltration. From Biofiltration To Promising Options In Gaseous Fluxes Biotreatment.* [Online] 2020. p. 92. Available from: https://doi.org/10.1016/B978-0-12-819064-7.00005-4 [Accessed 18.04.2020]

García, A.: *Descubre los sorprendentes usos del papel de lija.* [Online]. Available from: https://www.todo-mail.com/content.aspx?emailid=11201 [Accessed 22.04.2020]

Giani, H. et al.: *Rückgewinnung von Schleifkörnern aus Produktionsabfällen flexibler Schleifmittel (ReCAb).* [Online] 2018. Available from: https://www.dbu.de/OPAC/ab/DBU-Abschlussbericht-AZ-33215-01.pdf [Accessed 01.04.2020]

Heijungs R. et al.: *The Computational Structure of Life Cycle Assessment.* [Online] 2002. 7. pp. 4-7. Available from: https://books.google.fi/books?id=pLwqBgAAQBAJ&lpg=PR5&ots=jmXMz9HMpX&dq=life%20cycle%20assessment%20&lr&hl=nl&pg=PP1#v=onepage&q&f=false [Accessed 30.04.2020]

Henkel: *Einführung in die Lebenszyklusanalyse.* [Online]. p.6. Available from: https://www.henkel.de/resource/blob/51264/2181d473b3af531aee27117c554511eb/lebenszyklusanalysen-einfuehrung-data.pdf [Accessed 2.05.2020]

Huijbregts, M. et al.: *ReCiPe2016: a harmonised life cycle impact assessment method at midpoint and endpoint level. Int J Life Cycle Assess.* [Online] 2016. pp. 138-144. Available from: https://link.springer.com/content/pdf/10.1007/s11367-016-1246-y.pdf [Accessed 27.04.2020]

ifeu - Institut für Energie- und Umweltforschung Heidelberg GmbH: *Wirkungsabschätzung. Emissionskategorien.* [Online] 2020. Available from: https://www.ifeu.de/methoden/wirkungsabschaetzung/ [Accessed 29.04.2020]

Klöpffer, W.: *Life Cycle Assessment - From the Beginning to the Current State. Environmental Science and Pollution Research.* [Online] 1997. pp. 223–226. Available from: https://doi.org/10.1007/BF02986351 [Accessed 06.03.2020]

Loffler, M.: *Projektcontrolling In Theorie Und Praxis - Zielorientierte Optimierung Von Zeit, Kosten und Ressourcen Im Projektverlauf.* DIPLOMICA Verlag GMBH. [Online]. pp. 91-94. Available from: https://www.wiso-net.de/document/DIPL,ADIPL__9783961460366155 [Accessed 01.05.2020]

Novia University of Applied Sciences: *Technobothnia Service Concepts (ERUF).* [Online]. Available from: https://www.novia.fi/forskning/alla-projekt-pa-novia/hallbar-energiteknik/technobothnia-service-concepts-eruf [Accessed 06.04.2020].

PDR Recycling GmbH + Co KG: *Recycling of coated abrasives.* [Online] 2020. Available from: https://www.pdr.de/recycling-solutions-for-you/recycling-of-coated-abrasives/ [Accessed 01.04.2020]

Popular Woodworking: *How Sandpaper is Made.* [Video] 2016. Available from: https://www.youtube.com/watch?v=z3Db6ckGhes [Accessed 20.02.2020]

PRé, various authors: *SimaPro Database Manual - Methods Library.* [Online] 2019. p. 25. Available from: https://simapro.com/wp-content/uploads/2019/02/DatabaseManualMethods.pdf [Accessed 01.05.2020]

Rebitzer, G. et. al.: *Life cycle assessment Part 1: framework, goal and scope definition, inventory analysis, and applications. Environment International 30.* [Online] 2004. pp. 701-720. Available from: https://doi.org/10.1016/j.envint.2003.11.005 [Accessed 15.04.2020]

Regional Council of Ostrobothnia: *Technobothnia Service Concepts.* [Online]. Available from: https://www.obotnia.fi/rahoitus/hankerekisteri/technobothnia-service-concepts [Accessed 03.05.2020]

SAK: *Arbeiten In Finnland.* [Online] Available from: https://www.sak.fi/en/working-life/other-languages/german [Accessed 11.05.2020]

Schenke, L. et al.: *Recycling von Schleifkörnern aus Produktionsrückständen flexibler Schleifmittel.* [Online] 2018. Available from: http://www.recydepotech.at/media/121_Schenke.pdf [Accessed 01.04.2020]

SimaPro: *About SimaPro.* [Online]. Available from: https://simapro.com/ [Accessed 21.03.2020]

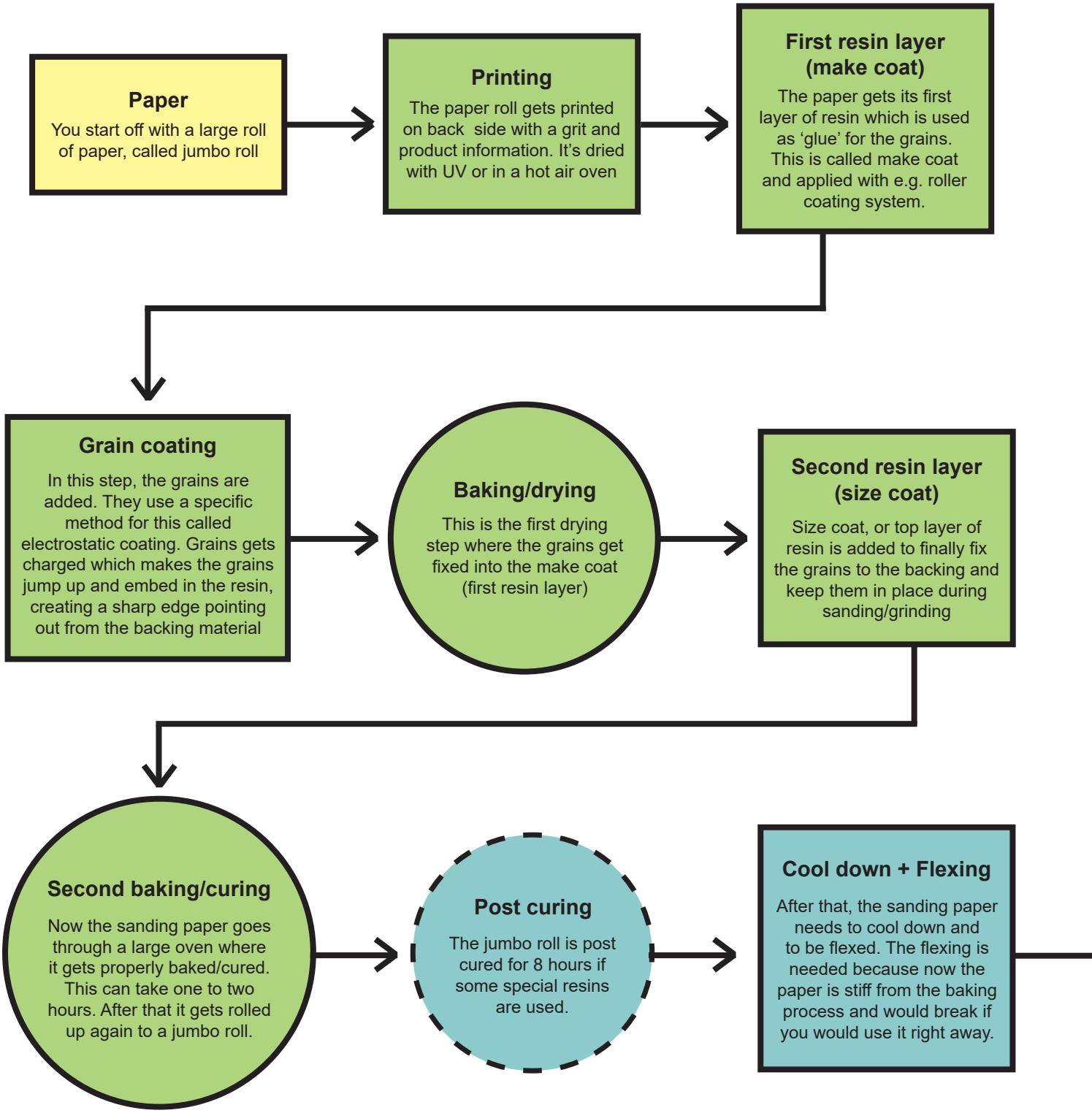
Statistics Finland: *Wages, Salaries and Labour Costs - Total earnings by employer sector.* [Online] 2018. Available from: https://www.stat.fi/tup/suoluk/suoluk_palkat_en.html [Accessed 14.03.2020]

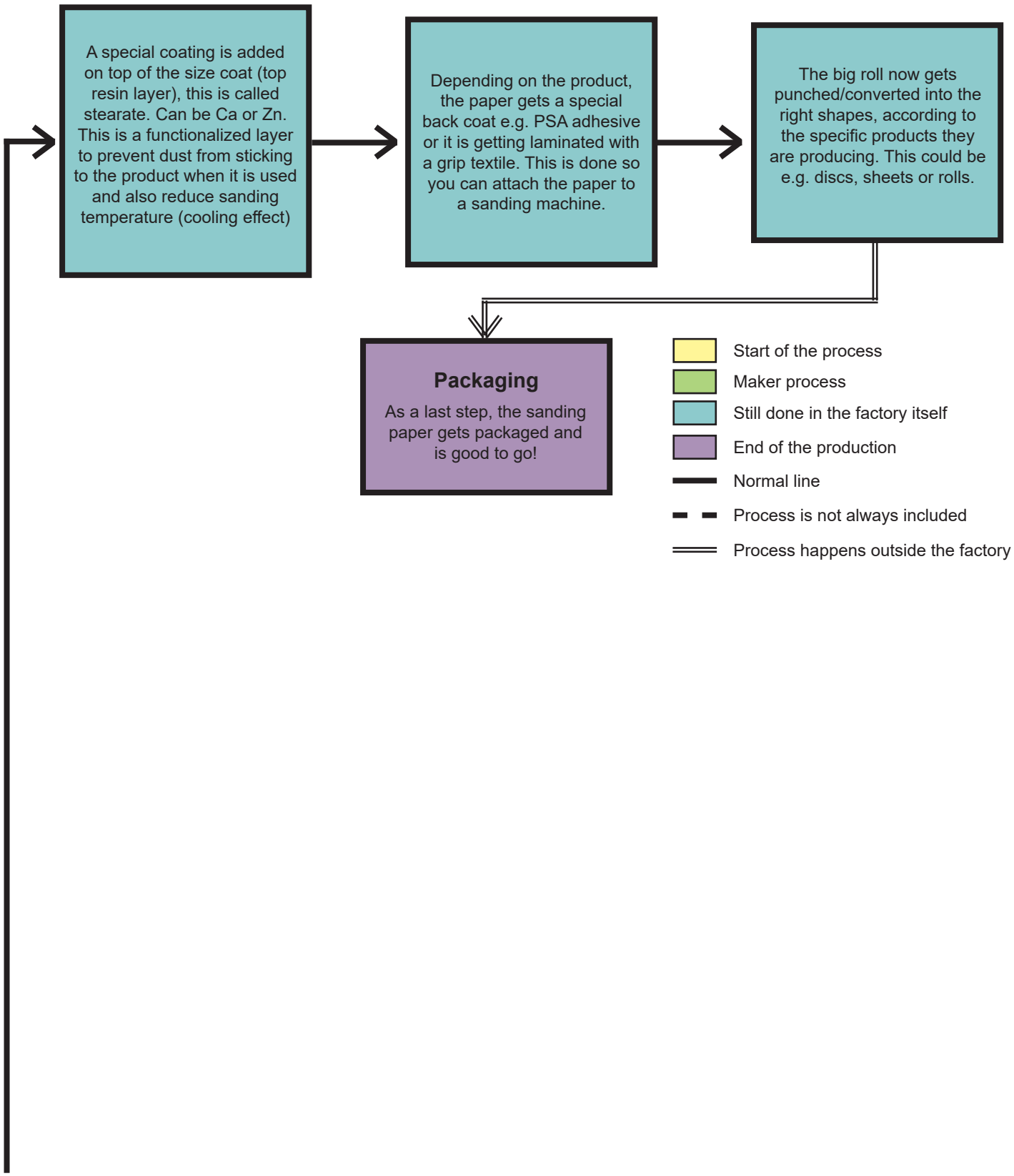
World Health Organisation: *Health statistics and information systems.* [Online]. Available from: https://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/ [Accessed 01.05.2020]

Zampori, L. et al.: *Guide for interpreting life cycle assessment result. JRC technical reports.* [Online] 2016. p. 4. Available from: https://publications.jrc.ec.europa.eu/repository/bitstream/JRC104415/lb-na-28266-en-n.pdf [Accessed 18.04.2020]

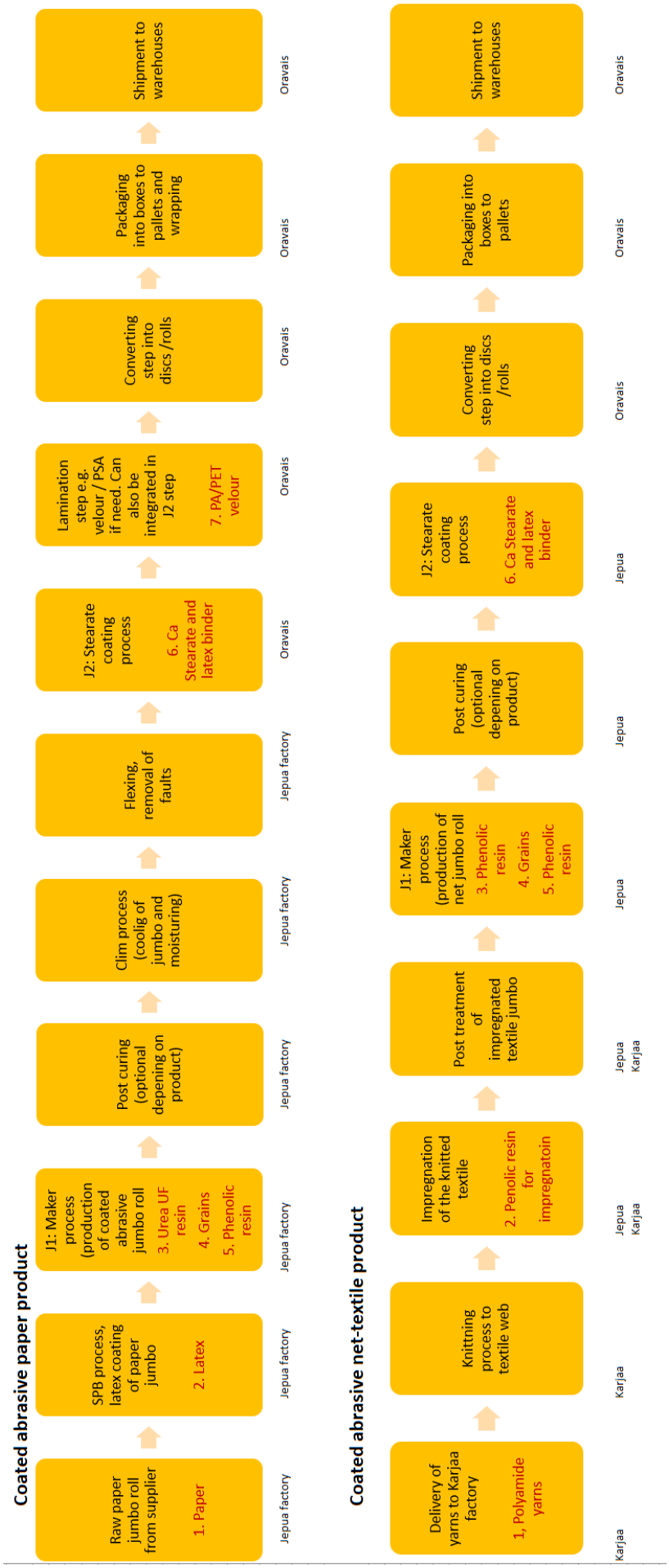
6. Appendices

Appendix A: Production of traditional sanding paper (own figure; Source: Popular Woodworking)




A special coating is added on top of the size coat (top resin layer), this is called stearate. Can be Ca or Zn. This is a functionalized layer to prevent dust from sticking to the product when it is used and also reduce sanding temperature (cooling effect)
Depending on the product, the paper gets a special back coat e.g. PSA adhesive or it is getting laminated with a grip textile. This is done so you can attach the paper to a sanding machine.
The big roll now gets punched/converted into the right shapes, according to the specific products they are producing. This could be e.g. discs, sheets or rolls.
Packaging
As a last step, the sanding paper gets packaged and is good to go!
Start of the process
Maker process
Still done in the factory itself
End of the production
Normal line
Process is not always included
Process happens outside the factory

Appendix B: Flowchart of all processes



Appendix C: Calculation of energy consumptions and CO2 emissions

kWh / produced m²	**2,6**	**kWh/m²**
bio CO2 (total)	9627,8	ton/a
fossile CO2 (total)	3743,8	ton/a
produced m²/a in total	35538462	m²/a
size of one product	0,017	m²/piece

(we assume, that it is the same for Gold and Abranet)

provided by Mirka
calculated (based on values by Mirka)
assumed

	electricity	heat consumption	total enery	percentage	percentage
Jepua	23400	55000			
Oravainen	6000	3700			
Karjaa	2200	2100			
total	**31600**	**60800**	**92400**	0,34	0,66

	production volume in m²/a	energy consumption (electricity+heat) in MWh/a	electricity consumption in MWh/a	heat consumption in MWh/a	**electricity consumption in kWh/m²**	**heat consumption in kWh/m²**	**electricity consumption in Wh/piece**	**heat consumption in Wh/piece**	**bio CO2 (total) in g/m²**	**fossile CO2 (total) in g/m²**	**bio CO2 (total) in g/piece**	**fossile CO2 (total) in g/piece**
Gold	1300000	3380	1156	2224	**0,89**	**1,71**	**15,12**	**29,08**	**270,91**	**105,35**	**4,6055**	**1,7909**
Abranet	346000	900	308	592	**0,89**	**1,71**	**15,12**	**29,08**	**270,91**	**105,35**	**4,6055**	**1,7909**

avoided heat:
7,27

Appendix D: Suppliers and warehouses

Transport		Provided by Mirka					Assumed		Value in SimaPro		Comment on assumption
Materials		Country	Shipment	From	Distance	Vehicle emission	Distance	Vehicle emission standard	Distance	Vehicle emission standard	
	Yarns for knitting	China	Sea Freight		not specified	not specified					Distance based on Google Maps
		Italy	Truck	Milan	not specified	not specified	2653	EURO4	2653	EURO4	Distance based on Google Maps
	Urea resins	Finland	Truck	Hamina	not specified	not specified	496	EURO4	496	EURO4	Distance based on Google Maps
	Phenolic resins to Karjaa	Finland	Truck	Hamina	not specified	not specified	225	EURO4	225	EURO4	Distance based on Google Maps
	Phenolic resins to Jepua	Finland	Truck	Hamina	not specified	not specified	496	EURO5	496	EURO4	Distance based on Google Maps
	Latex	Germany	Truck	Langelsheim	not specified	not specified	2005	EURO4	2005	EURO4	Distance based on Google Maps
	Base paper	Finland	Truck	Pietersaari	not specified	not specified	36,3	EURO4	36,3	EURO4	Distance based on Google Maps
	Aluminum oxide	Austria	Truck	Villach	not specified	not specified	2545	EURO4	2545	EURO4	Distance based on Google Maps
		Brazil	Sea Freight	Sao Paulo	not specified	not specified	13840		13840		Distance based on Google Maps
	Yarns for grip cloth	Italy	Truck	Milan	not specified	not specified	2653	EURO4	2653	EURO4	Distance based on Google Maps
	Zink stearate powder	Germany	Truck	Bad Münstereifel	not specified	not specified	2249	EURO4	2249	EURO4	Distance based on Google Maps
	Ca Stearate powder	Germany	Truck	Bad Münstereifel	not specified	not specified	2249	EURO4	2249	EURO4	Distance based on Google Maps
	Fillers e.g calciumcarbonate	Austria	Truck	Gummern	not specified	not specified	1874	EURO4	1874	EURO4	Distance based on Google Maps

Transport			Provided by Mirka	Assumed	Value in SimaPro	Comment on assumption
Between facturies	From	To	Distance	Distance	Distance	
plants	Karjaa	Jepua	not specified	483	483	Distance based on Google Maps
	Jepua	Oravais	not specified	20,5	20,5	Distance based on Google Maps

	Transport	Provided by Mirka					Assumed		Value in SimaPro		Comment on assumption
	To warehouses	Warehouse	Place	Shipment	Distance	Vehicle emission	Distance	Vehicle emission standard	Distance	Vehicle emission standard	
		Finland	Vantaa	Truck	not specified	not specified	437	EURO4	437	EURO4	Distance based on Google Maps
		Belgium	Opglabbeek	Truck	not specified	not specified	2274	EURO4	2274	EURO4	Distance based on Google Maps
		Russia	Leningrad region Gorel	Truck	not specified	not specified	679	EURO4	679	EURO4	Distance based on Google Maps
		Turkey	Kocaeli	Truck	not specified	not specified	3106	EURO4	3106	EURO4	Distance based on Google Maps
		Brazil	Barueri	Sea	not specified	not specified	13840		13840		Distance based on Google Maps
		Mexico	Tepotzotlan	Sea	not specified	not specified	13170		13170		Distance based on Google Maps
		USA	Plainfield IN	Sea	not specified	not specified	14978		14978		Distance based on Google Maps
		Singapore	No.1 Changi south lane	Sea	not specified	not specified	10074		10074		Distance based on Google Maps
		China	Minhang district Shang	Air	not specified	not specified	7371		7371		Distance based on Google Maps
		India	Tehsil pataudi, gurgaor	Air	not specified	not specified	5356		5356		Distance based on Google Maps

1st step

All weights are in kg/m²

	Gold	Abranet	
Paper	0,1550	0,2450	
Backing impgr	0,0070	0,1300	
Backing	0,1275	0,2450	
make coat	0,0028	0,0200	
Grain coat	0,1370	0,0900	
Size coat	0,1125	0,0615	
Grip velour	0,0625	0,0000	
Supersize coat	0,0175	0,0055	
total weight per m²	**0,6218**	**0,7970**	add up all values of the material

2nd step

weight in kg	Gold	Abranet	
weight for 1,46m² jumbo	0,9078	1,1636	total weight per m²*1,46m²
weight for 60 disc (without holes) in Kg	0,6808	0,8727	weight per disc*60 disc
weight for waste are 25% (Mirka)	0,2269	0,2909	weight for 1,46m²*25%
weight per disc when you get 60 disc of 1,46m²	0,0113	0,0145	(weight for 1,46m²-weight for waste are 25% (Mirka))/60disc

3rd step

	Gold			Abranet	
Size in m²	disc	small hole	big hole	disc	
diameter	0,1500	0,0090	0,0150	0,1500	given from Mirka
radius	0,0750	0,0045	0,0075	0,0750	diameter/2
size for one disc/hole (with holes)	0,0171	0,0004	0,0002	0,0177	pi*r^2

the small and big holes are measured of the waste, Mirka gave the team

4th step

		Disc per year	
total abranet (year)	346 000	19222222	total Abranet in m²/ 0,018 m² (rounded up)
total gold (year)	1 300 000	76470588	total Gold in m²/0,017 m² (rounded down)
Total weight (Abranet)		279592	total disc per year*weight per disc
Total weight (Gold)		867707	total disc per year*weight per disc

5th step

total weight per warehouse

Abranet	27959	total weight/10
Gold	86771	total weight/10

Idea is to ship the same values to each warehouse for a year
(ten warehouses all over the word)

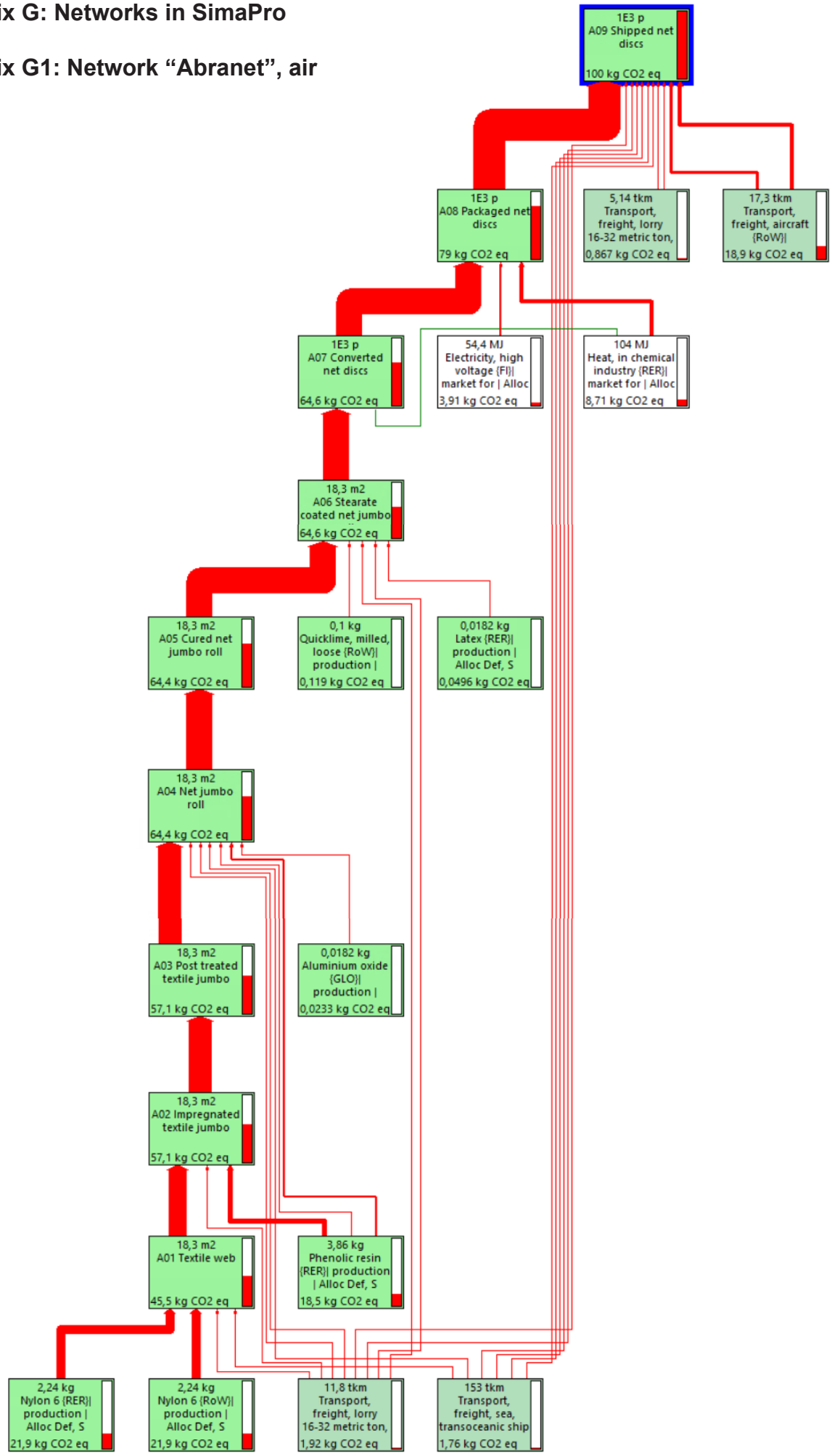
1st step: adding all Materials to get the total weight of one m² of the jumbo roll (information are only given per m²)
2nd step: calculating weight for 1,46 m² because the jumbo roll is 1,46 m wide and the teams assumed for 1 m length, c
calculating the waste, result is getting the weight per disc
3rd step: calculation of the sice per disc. Gold has holes, Abranet has no holes
4th step. calculating the produced disc per yer
5th step: calculating the weight of the discs per warehouse

Appendix F: Assumed values for the weight of the layers

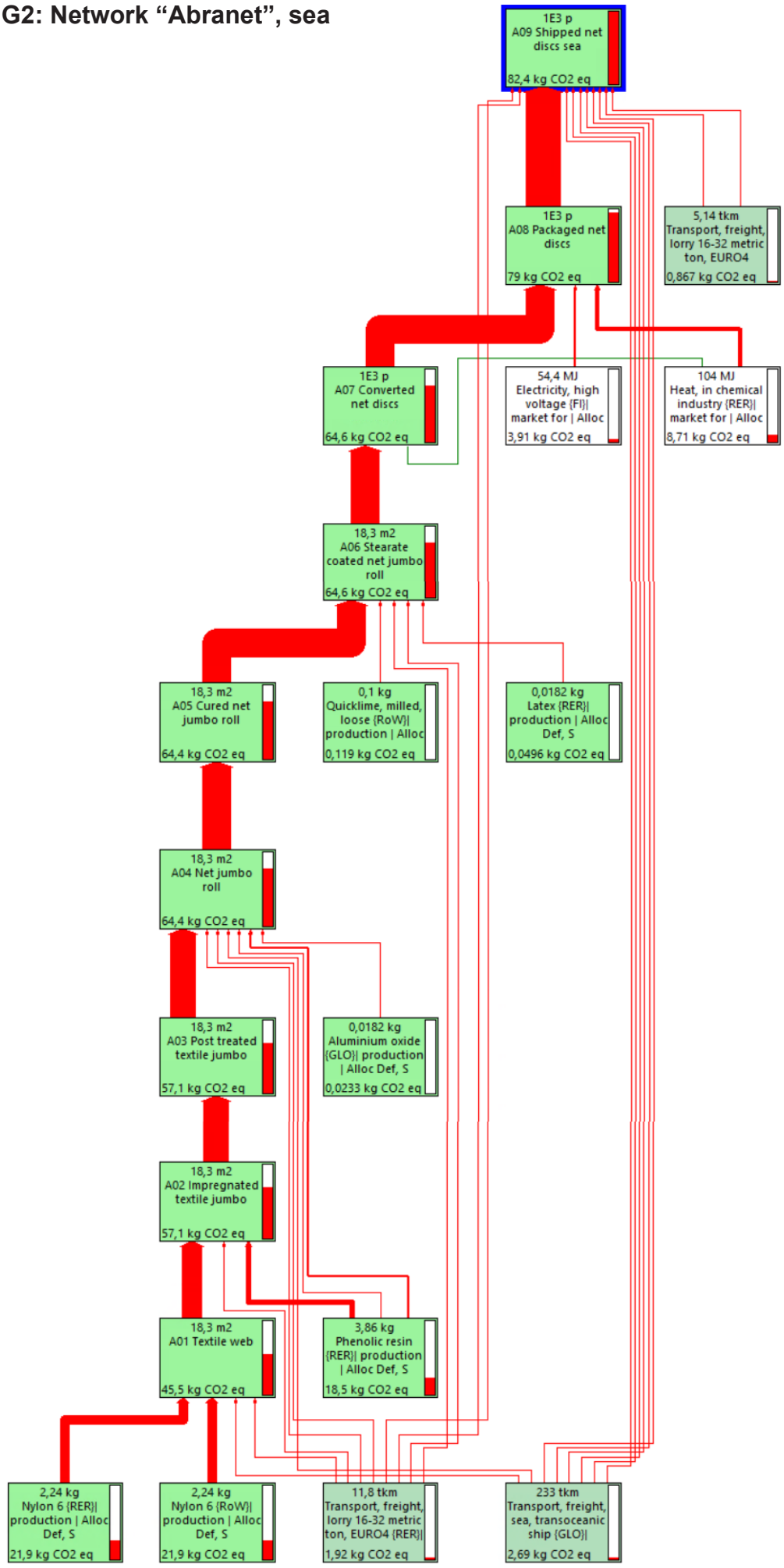
		Provided by Mirka		Assumed	Value in SimaPro	Comment on assumption
		MIN g/m2	MAX g/m2	g/m2	g/m2	
Materials						
Gold	Paper	90	165	155	155	Number given by Mirka (email)
	Latex		7	7	7	Only 1 number provided, so we took this one
	Urea	5	50	27,5	27,5	Average of both numbers
	Aluminim oxide	10	264	137	137	Average of both numbers
	Phenolic resin	20	205	112,5	112,5	Average of both numbers
	Ca stearate	10	25	17,5	17,5	Average of both numbers
	Latex binder	?	?			Not provided yet
	Polyamide	55	70	62,5	62,5	Average of both numbers
Abranet	Polyamide yarns	165	325	245	245	Average of both numbers, in SimaPro we split the number in 2 because the product comes from 2 different places and we don't know how much product comes from which place
	Phenolic resin	115	145	130	130	Average of both numbers
	Phenolic resin	5	35	20	20	Average of both numbers
	Aluminum oxide	10	170	90	90	Average of both numbers
	Phenolic resin	7	116	61,5	61,5	Average of both numbers
	Ca stearate	3	8	5,5	5,5	Average of both numbers
	Latex binder	?	?			Not provided yet

Appendix G: Networks in SimaPro

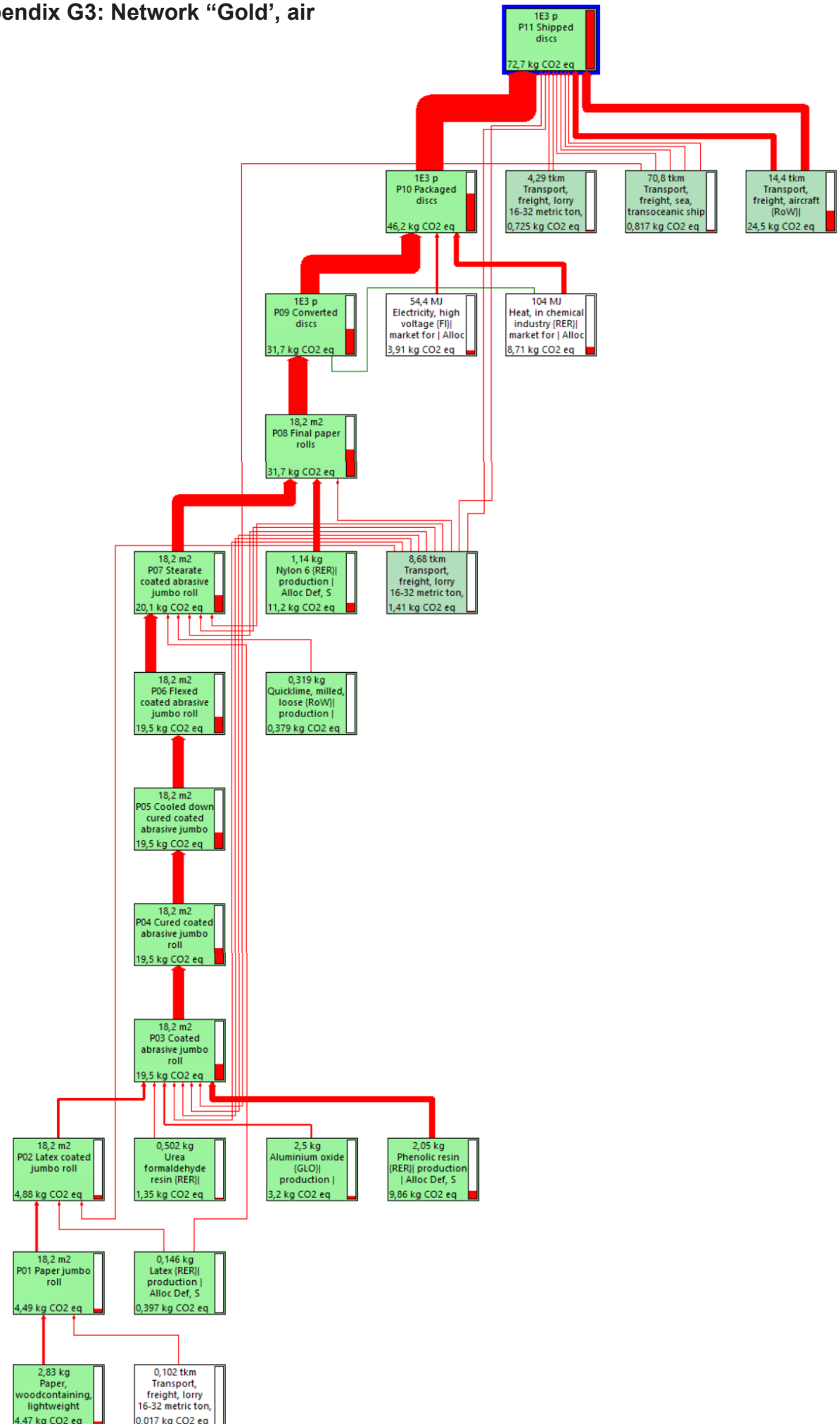
Appendix G1: Network “Abranet”, air



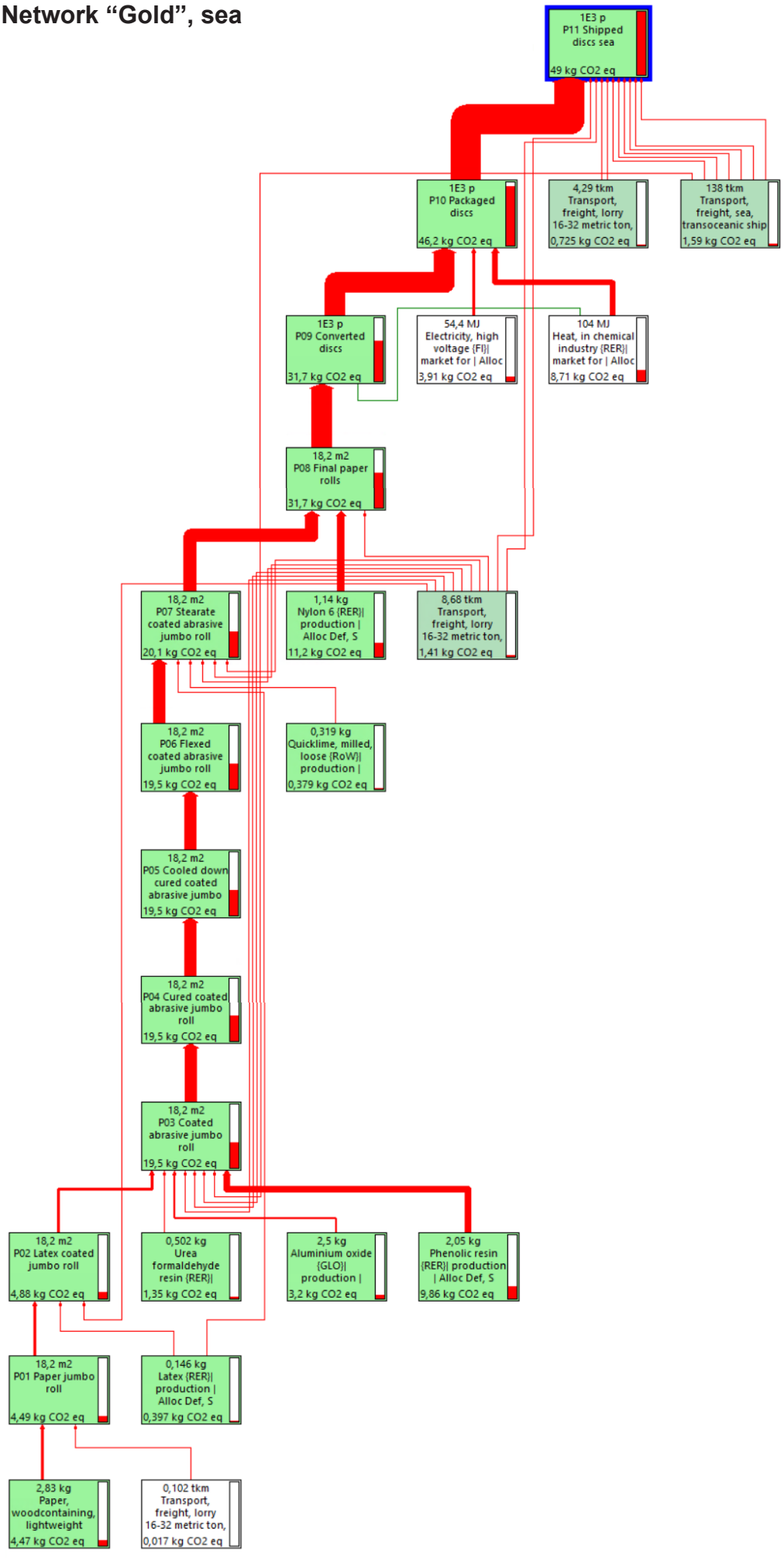
Appendix G2: Network “Abranet”, sea



Appendix G3: Network “Gold’, air



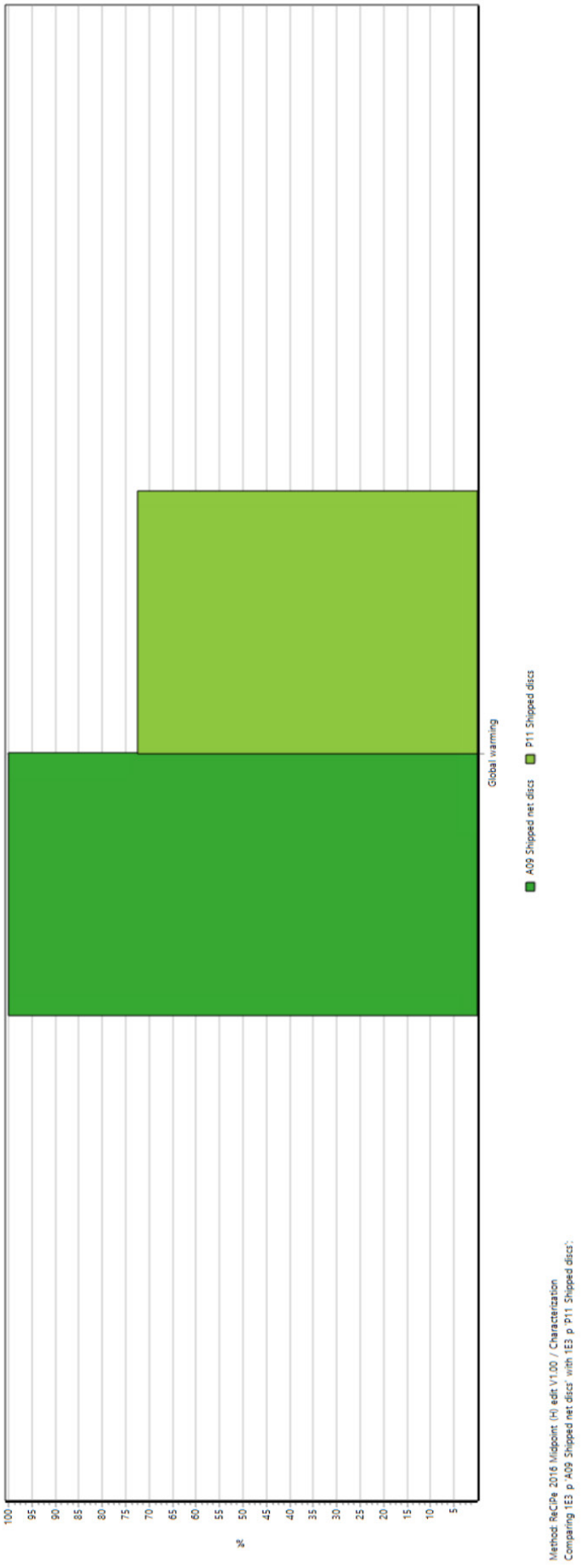
Appendix G4: Network “Gold”, sea



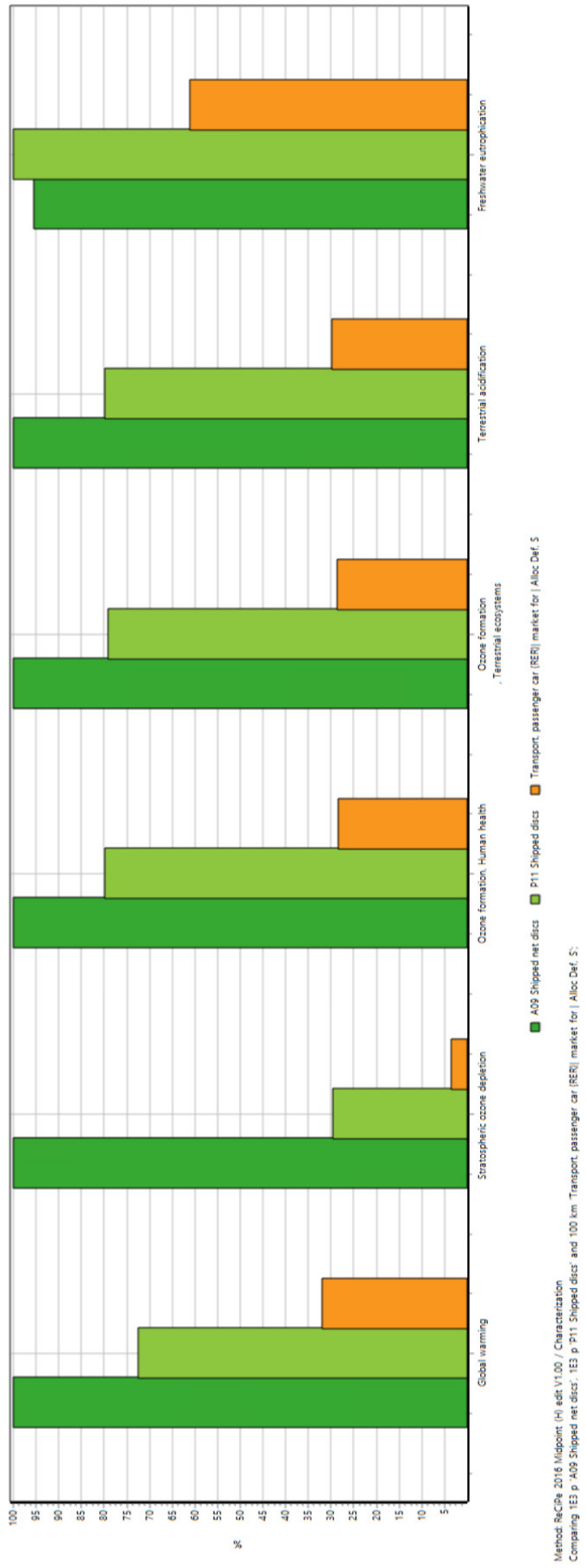
Appendix H: Results from SimaPro (Impacts)

Appendix H1: Midpoint comparison “Abranet” - “Gold”

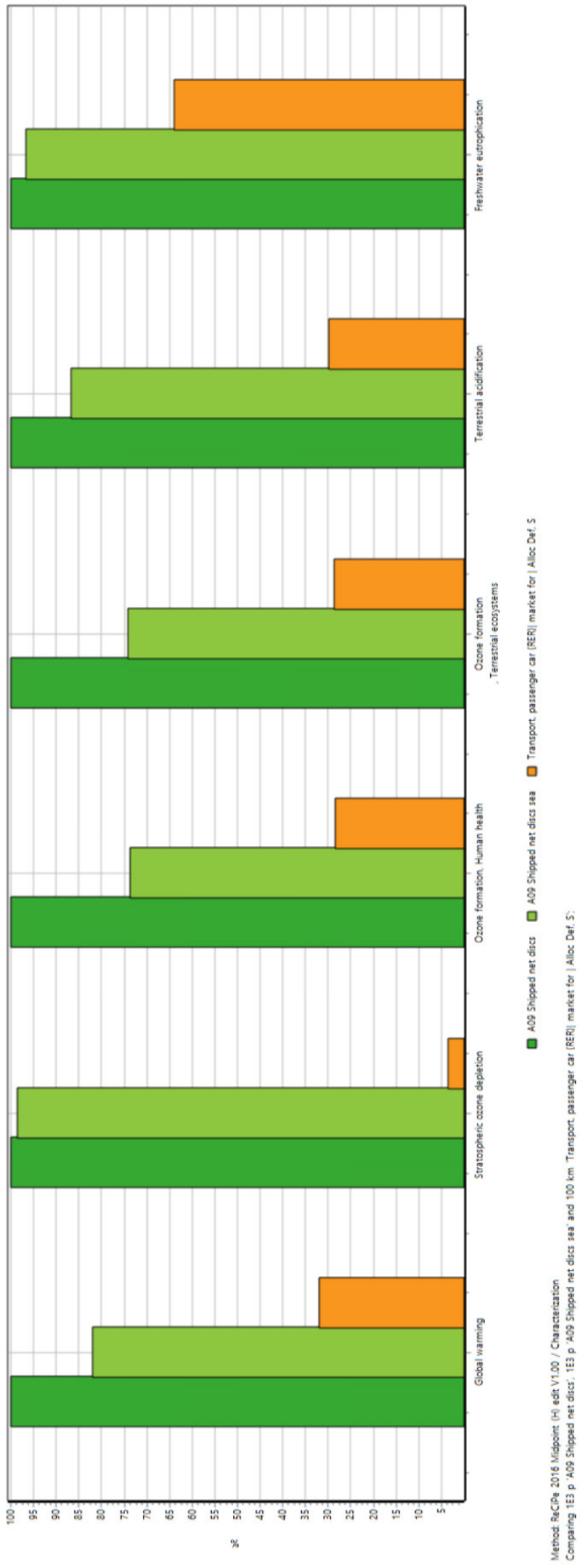
Appendix H2: Midpoint comparison “Abranet” - “Gold”, Global warming



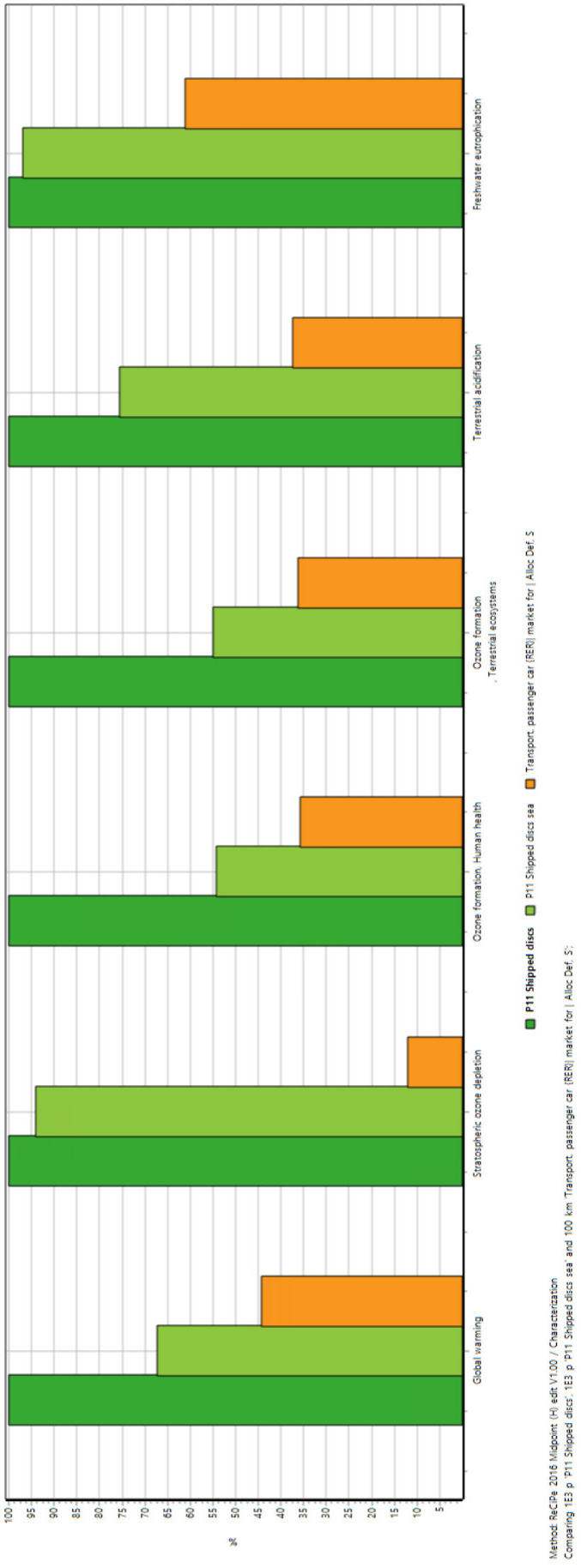
Appendix H3: Midpoint comparison “Abranet” - “Gold” - “Car”



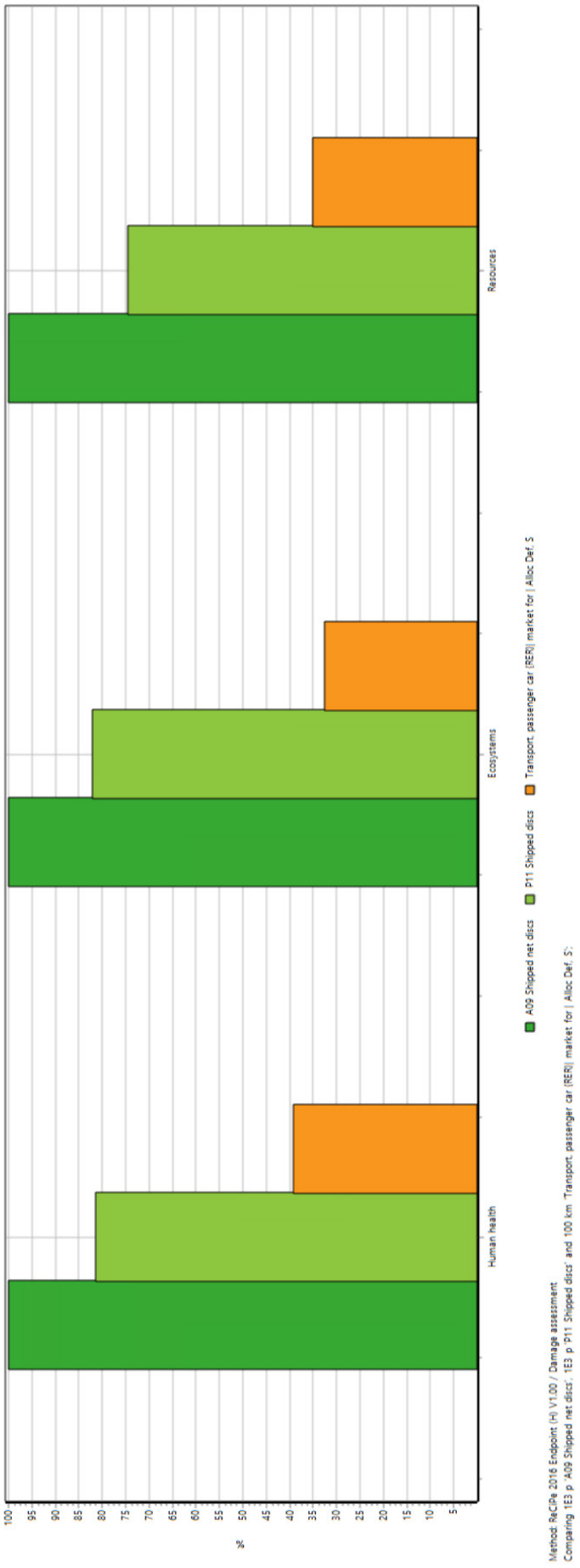
Appendix H4: Midpoint comparison “Abranet”, air - sea



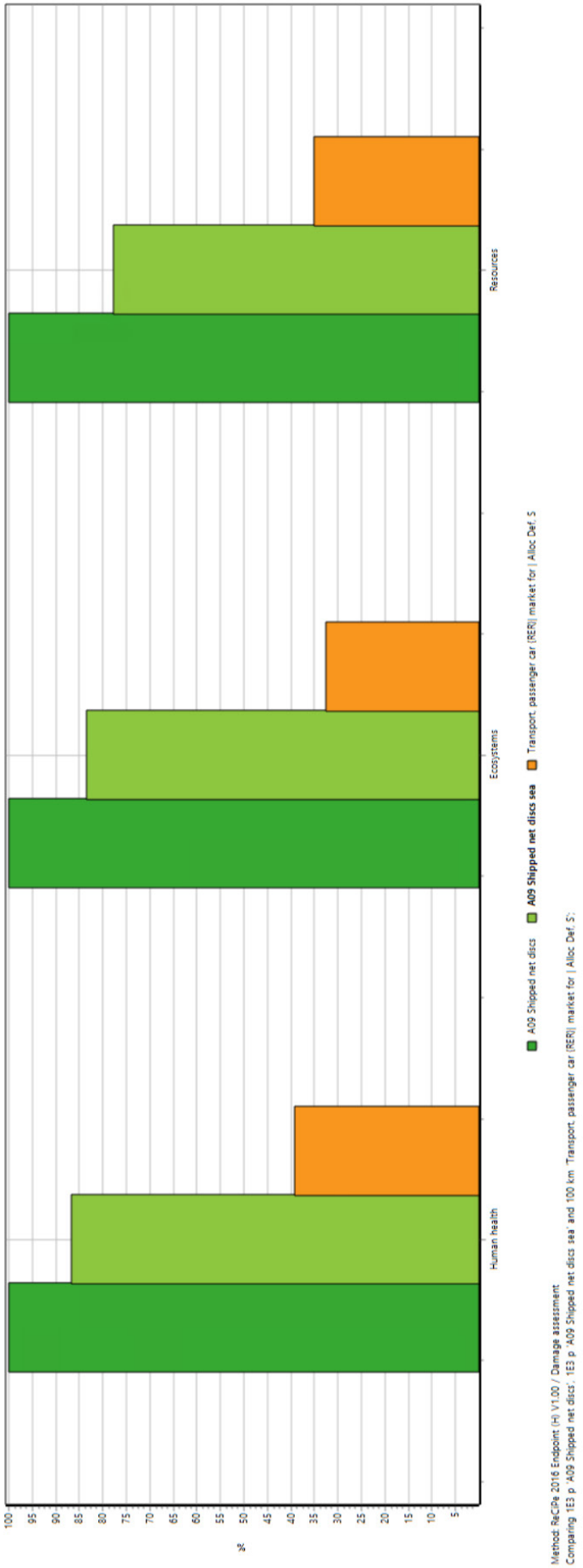
Appendix H5: Midpoint comparison “Gold”, air - sea



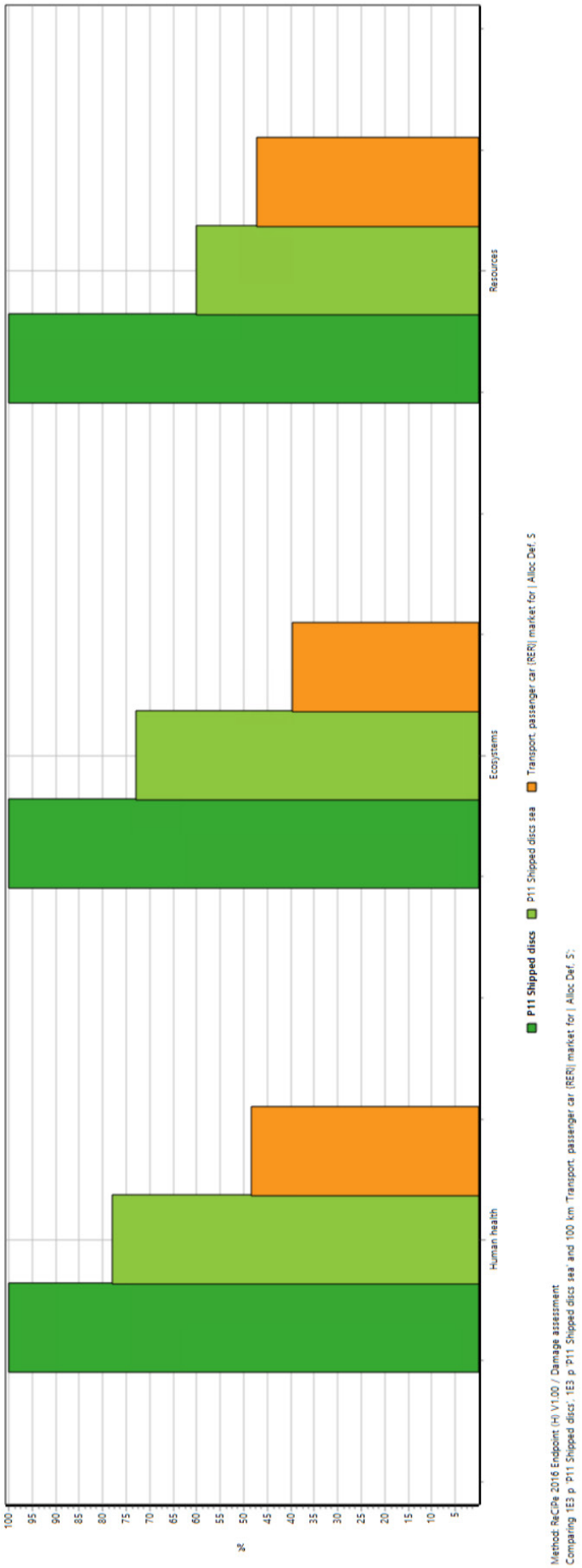
Appendix H6: Endpoint comparison “Abranet” - “Gold” - “Car”



Appendix H7: Endpoint comparison “Abranet”, air - sea



Appendix H8: Endpoint comparison “Abranet”, air – sea



Appendix I: Lessons learned

All in all, the processing of the project went without major problems. The team started working on the project in time and dealt with the topics comprehensively. In the beginning, a lot of time was spent to understand the functionality of the software before the modelling could be initiated. Since the main focus of the project was on studying the software, this was not a big problem and the team managed the modelling in time.

An important issue was data collection and interpretation. The software requires a considerable amount of detailed information as input, which was not all collected in the limited period of time. Therefore a large number of calculations and assumptions were conducted. The challenge for the team was to get the correct data for SimaPro. The team should have communicated more clearly which data was required exactly. In addition, the company could have been contacted more often if there was no answer for a longer period of time. In the future, deadlines can be set to minimize this problem. Maybe additional meetings with the company would have been useful to understand the whole production process better, since understanding problems occurred many times.

Regarding teamwork, it can be said that the meetings could have been structured more effectively. Nevertheless, the team came up with good solutions together. In addition, problems that occurred could sometimes have been identified earlier in order to be able to continue working on the project in time. The team missed a person who can push the other members.

Appendix J: Project management

Appendix J1: Earned value analysis

Earned value analysis (EVA) is an important part of project management. EVA is used to identify and analyse the progress in a project at any point. It indicates in which area the costs were higher and in which area costs were saved during the project. In addition, it also indicates if the project is behind schedule.
To carry out an EVA, the planned costs, the current costs and the cumulative costs are required. As a basis, the WBS or the work weeks can be chosen. This second option is used when something is elaborated during the project, instead of producing something. It gives an early warning if the budget is exceeded or the times were not kept.

Parts of the Earned values

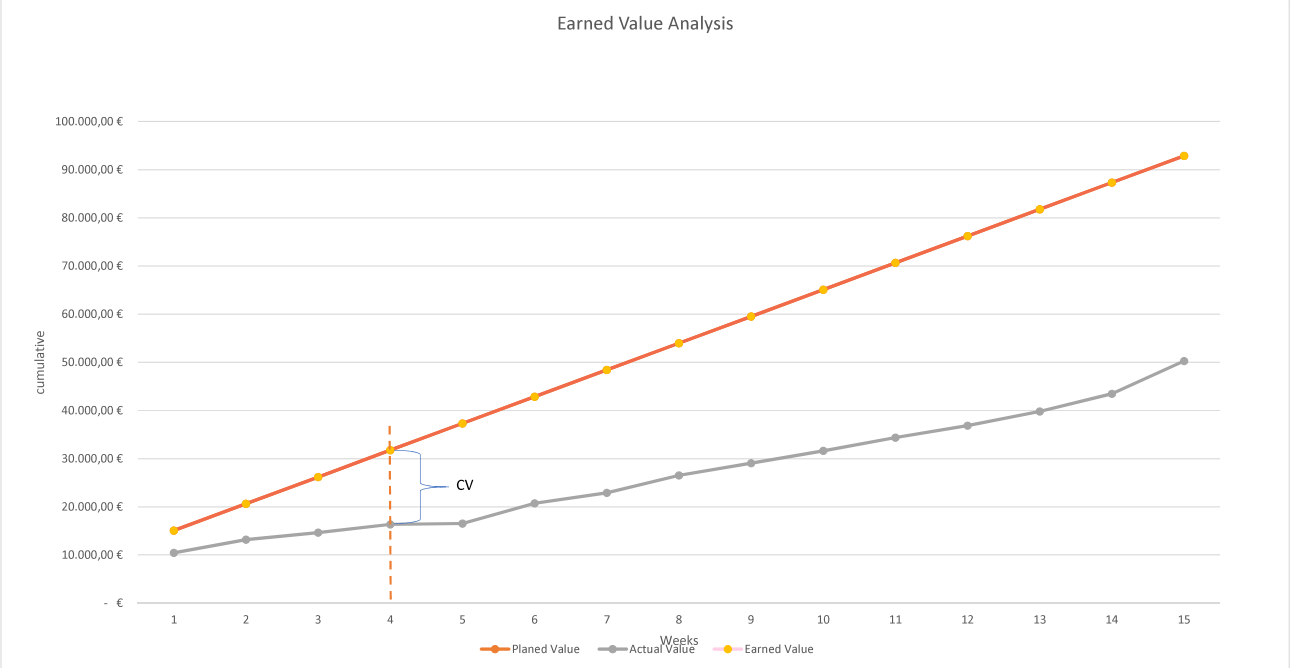
- Plan Cost (PC): costs that are initially determined and planned.
- Actual Cost (AC): costs that were issued up to the key date.
- Cumulative Cost: the weekly costs are added to the previous week.
- Earned Value (EV): the costs that were achieved up to the cut-off date, taking into account the costs incurred to date, as well as the percentage of the project's performance so far.
- Cost variance (CV): indicates the difference between actual cost and earned value.
- Scheduled variance (SV): indicates the difference between planned cost and earned value.
- Cost performance index (CPI): is the same as CV but in percentage terms.
- Scheduled performance index(SPI): is the same as SV but in percentage terms.

For the project:
The project has a planned working hour of 2250 hours. The 2250 working hours arise from four team members working for 15 weeks with a time of 37,5 hours per week for each member. To get the actual value, the working hours per week are multiplied with 37,04 €.

37,04 € consist of:

- 20,53 € basic salary
- Multiplied with a factor of 1,8.

The factor includes for example taxes and insurance, which the employer pays for the employees.
Basic salary was taken from appedix J7



Looking at week four in the diagram and the table, it indicates that the project goes well since the actual costs are lower than the planned cost. It is important to look at the earned value. Despite the savings in costs, the work was carried out 100 percent and the project was not behind scheduled.The previously planned period takes into account any difficulties or delays. Since there were no difficulties, the project was realised with less working time.

	Planed cost				Actual cost							
Week	Extra	Time	Costs	cumulative (PC)	Time	Cost	cumulative (AC)	Earned Value	SC	CV	SPI	CPI
1	9.500,00 €	150	15.056,60 €	15.056,60 €	25,5	10.444,62 €	10.444,62 €	15.056,60 €	- €	4.611,98 €	1	1,442
2	- €	150	5.556,60 €	20.613,20 €	74,0	2.741,26 €	13.185,88 €	20.613,20 €	- €	7.427,32 €	1	1,563
3	- €	150	5.556,60 €	26.169,80 €	39,0	1.444,72 €	14.630,59 €	26.169,80 €	- €	11.539,21 €	1	1,789
4	30,00 €	150	5.586,60 €	31.756,40 €	46,0	1.734,02 €	16.364,62 €	31.756,40 €	- €	15.391,78 €	1	1,941
5	- €	150	5.556,60 €	37.313,00 €	4,0	148,18 €	16.512,79 €	37.313,00 €	- €	20.800,21 €	1	2,260
6	- €	150	5.556,60 €	42.869,60 €	114,0	4.223,02 €	20.735,81 €	42.869,60 €	- €	22.133,79 €	1	2,067
7	- €	150	5.556,60 €	48.426,20 €	58,5	2.167,07 €	22.902,88 €	48.426,20 €	- €	25.523,32 €	1	2,114
8	- €	150	5.556,60 €	53.982,80 €	98,0	3.630,31 €	26.533,20 €	53.982,80 €	- €	27.449,60 €	1	2,035
9	- €	150	5.556,60 €	59.539,40 €	68,0	2.518,99 €	29.052,19 €	59.539,40 €	- €	30.487,21 €	1	2,049
10	- €	150	5.556,60 €	65.096,00 €	69,5	2.574,56 €	31.626,75 €	65.096,00 €	- €	33.469,25 €	1	2,058
11	- €	150	5.556,60 €	70.652,60 €	74,0	2.741,26 €	34.368,00 €	70.652,60 €	- €	36.284,60 €	1	2,056
12	- €	150	5.556,60 €	76.209,20 €	67,5	2.500,47 €	36.868,47 €	76.209,20 €	- €	39.340,73 €	1	2,067
13	- €	150	5.556,60 €	81.765,80 €	79,0	2.926,48 €	39.794,95 €	81.765,80 €	- €	41.970,85 €	1	2,055
14	- €	150	5.556,60 €	87.322,40 €	99,0	3.667,36 €	43.462,30 €	87.322,40 €	- €	43.860,10 €	1	2,009
15	- €	150	5.556,60 €	92.879,00 €	184,0	6.816,10 €	50.278,40 €	92.879,00 €	- €	42.600,60 €	1	1,847
		2250	92.879,00 €		1100	50.278,40 €						

Appendix J2: Updated time schedule

Pos.	Task	start	end	duration [weeks]	responsible	Status	Week 0 (3.2.-9.2.)	1 (10.2.-16.2.)	2 (17.2.-23.2.)	3 (24.2.-1.3.)	4 (2.3.-8.3.)	5 (9.3.-15.3.)	6 (16.3.-22.3.)	7 (23.3.-29.3.)	8 (30.3.-5.4.)	9 (6.4.-12.4.)	10 (13.4.-19.4.)	11 (20.4.-26.4.)	12 (27.4.-3.5.)	13 (4.5.-10.5.)	14 (11.5.-17.5.)	15 (18.5.-24.5.)
1	**EPS Project**	**06.02.**	**18.05.**		**team**																	
2	**define project and team**																					
3	define tasks and objectives (& Meeting Mirka)	**06.02.**	**09.02.**	1	Dorien	finished																
4	define team roles	**06.02.**	**09.02.**	1	Dorien	finished																
5	**create LCA**																					
6	**do preperation**																					
7	do research for LCA	**10.02.**	**23.02.**	2	Marcos	finished																
8	learn how to use SimaPro	**10.02.**	**01.03.**	3	Marcos	finished																
9	understand process of the discs	**10.02.**	**16.02.**	1	Dorien	finished																
10	◊ preparation LCA finished	01.03.	01.03.	0						◊												
11	**collect data**																					
12	define which data are necessary	**02.03.**	**08.03.**	1	Claudia	finished																
13	collect data from Mirka	**09.03.**	**22.03.**	2	Team	finished																
14	◊ collecting data finished	22.03.	22.03.	0									◊									
15	**create LCA for Gold**																					
16	analyse data	**23.03.**	**29.03.**	1	Dorien, Claudia	finished																
17	integrate data in SimaPro	**30.03.**	**19.04.**	3	Dorien, Claudia	finished																
18	interpret the results	**20.04.**	**10.05.**	3	Dorien, Claudia	finished																
19	◊ LCA Gold finished	10.05.	10.05.	0																◊		
20	**create LCA for Abranet**																					
21	analyse data	**23.03.**	**29.03.**	1	Dorien, Claudia	finished																
22	integrate data in SimaPro	**30.03.**	**19.04.**	3	Dorien, Claudia	finished																
23	interpret the results	**20.04.**	**10.05.**	3	Dorien, Claudia	finished																
24	◊ LCA Abranet finished	10.05.	10.05.	0																◊		
25	**improve waste management**																					
26	**do preperation**																					
27	analyse the process	**17.02.**	**01.03.**	2	Marcos, Marvin	finished																
28	identify improvement potential: brainstorming	**02.03.**	**15.03.**	2	Team	finished																
29	◊ preparation waste management finished	15.03.	15.03.	0								◊										
30	**find solutions**																					
31	investigate usage for waste	**16.03.**	**29.03.**	2	Marcos, Marvin	finished																
32	analyse material recovery process	**16.03.**	**05.04.**	3	Marcos, Marvin	finished																
33	find business ideas	**06.04.**	**03.05.**	4	Marcos, Marvin	finished																
34	◊ solutions waste management finished	03.05.	03.05.	0															◊			
35	**prepare reports**																					
36	write mid term report	**10.02.**	**22.03.**		Team	finished																
37	write final report	**23.03.**	**03.05.**	10	Team	finished																
38	finish final report & prepare presentations	**04.05.**	**15.05.**	1	Dorien, Claudia	in process																
39	◊ reports & presentations finished	14.05.	15.05.	0																	◊	

Appendix J3: Individual time-follow-up

Claudia Eimert

Kind of work	Date	Hours	Comments	Total Time 306,5
PM class	05.02.2020	1,5		
Team building class	07.02.2020	1,5		
Meeting	07.02.2020	1,5		
Simapro Coffee tutorial	07.02.2020	1,0	First experience with SimaPro	
PM class	10.02.2020	1,5		
Swedish class	10.02.2020	1,5		
Simapro Wood tutorial	10.02.2020	1,5		
English class	11.02.2020	1,5		
English homework	12.02.2020	2,0	Preparing presentation for English class	
English class	13.02.2020	1,5		
Meeting with Mirka	14.02.2020	2,0	Everything got cleared out about the project	
Simapro Wood tutorial	14.02.2020	2,0		
Swedish class	14.02.2020	1,5		
PM presentation	15.02.2020	2,5	Preparing presentation for PM	
Belbin questionnaire	15.02.2020	1,0	Doing Belbin test	
PM class	17.02.2020	1,5		
WBS	17.02.2020	3,0	Preparing work breakdown structure	
Meeting	17.02.2020	1,5	Doing the social group contact	
Simapro meeting with Niklas	17.02.2020	1,0	Asking questions, getting answer	
LCA & relevant data	19.02.2020	3,0	Research LCA Research production of sanding discs	
Timeline	19.02.2020	0,5	Starting preparation of time table & timeline	
Risk analyse, timeline, responsibilities	24.02.2020	2,0	Starting risk analyse add information to timeline divide tasks	
Fixing timetable	24.02.2020	0,5	Fixing my timetable	
Midterm Report	24.02.2020	1,0	Preparing document for midterm report	
Midterm Report	24.02.2020	1,5	Starting with chapter "presentation of company"	
Risk analyse	25.02.2020	1,0	Changing design of risk analyse & adding sheets for	
Midterm Report	25.02.2020	2,5	Starting with chapters "about project" and "mission"	
English homework	26.02.2020	2,5	English homework article about culture	
Midterm Report	26.02.2020	3,0	Continuing with chapter "mission" & write chapter "stakeholders"	
Meeting Mirka	27.02.2020	3,0	Meeting at Mirka with Mats (tour through production and discussing the questions)	
Swedish homework	08.03.2020	2,0	Doing Exercise 1, 3 and 4	
PM class	09.03.2020	1,5		
Swedish class	09.03.2020	1,5		
Meeting	09.03.2020	1,5	See minutes document	
Minutes of the meetings	10.03.2020	1,5	Finishing minutes of the meetings from 14.2., 27.2. and 9.3.	
Swedish Homework	10.03.2020	2,0	Learning vocabulary	
Swedish class	11.03.2020	1,5		
English class	11.03.2020	1,5		
Meeting	11.03.2020	1,0	SimaPro	
Literature about project management	11.03.2020	2,5	Reading literature (PMI and fundamentals ...) and reading slides from Roger >> creating summary	
Stakeholder	11.03.2020	2,0	Identifying and analysing Stakeholders	
Project management: scheduling	12.03.2020	3,0	Writing summary of PMI book & slides from Roger; preparing arrow chart, timeline & bar chart	
Project management: scheduling	12.03.2020	2,0	Writing summary of slides from Roger & changing structure of mid term report	
Meeting	13.03.2020	2,5		
Scheduling & minutes of meeting	14.03.2020	3,0	Changing WBS, Arrow chart & bar chart; writing minutes of meeting 13.03.	
Mid term report	14.03.2020	2,0	Writing chapters WBS & scheduling	
Mid term report	15.03.2020	2,5	Writing chapters risk management & stakeholder analysis	
Mid term report	15.03.2020	4,0	Reading; doing corrections & some changes in the report, creating Project hierarchy	
PM class	16.03.2020	1,5		
Meeting	16.03.2020	1,5		
Swedish class	16.03.2020	1,5		
Meeting	17.03.2020	1,5		
Meeting	19.03.2020	1,0		
Meeting	20.03.2020	1,0	RACI matrix, mid term, problems link SimaPro, e-mail Shiva	
Mid term report	20.03.2020	3,5	Changing "arrow chart", rewriting chapter "objectives"	

Mid term report	21.03.2020	3,0	Rewriting my texts and including comments from Shiva
Mid term report	22.03.2020	3,0	Reading, doing some changes
Mid term report	23.03.2020	4,0	Reading, discussing, starting new version "Definition of LCA" (research and writing)
Mid term report	24.03.2020	4,0	Writing text about LCA, designing figures; reading
Mid term report	24.03.2020	1,5	Creating final document
Mid term report	25.03.2020	3,5	Creating new mid term
Meeting	25.03.2020	1,0	Getting to know MC Teams, discussing presentation
Mid term report	26.03.2020	1,5	Creating references
English exercises	26.03.2020	1,0	
Mid term report & presentation	27.03.2020	2,5	Reading, checking, changing chapter "conclusion"
English exercises	27.03.2020	2,0	
Mid term presentation	28.03.2020	1,5	Thinking about my content & improving my slides
Mid term presentation	29.03.2020	1,0	Preparing my text for the presentation
Meeting	29.03.2020	1,0	Discussing presentation
Mid term presentation	29.03.2020	2,0	Corrections, changes and design of presentation
Mid term presentation	29.03.2020	2,0	Practising presentation
Class: presentations	30.03.2020	4,5	Mid term presentation
English presentation	30.03.2020	1,5	Preparing culture presentation
Swedish class	30.03.2020	1,5	Watching Swedish videos & doing exercises
Swedish homework	31.03.2020	0,5	Describing my family
English exercises	31.03.2020	1,0	
Meeting	01.04.2020	1,5	Comments midterm, what to do next
Peer evaluation	01.04.2020	1,5	Peer evaluation
Meeting	02.04.2020	3,0	Modelling in SimaPro
Summary	02.04.2020	1,0	Writing summary of the meeting & of the questions for Mats and NIklas
Meeting	03.04.2020	1,5	Modelling in SimaPro
E-mails	03.04.2020	1,0	Writing e-mails to Mats & Niklas
Research	04.04.2020	1,5	Research about LCA, starting structure for final report
Research	05.04.2020	2,5	Research about LCA & functional unit
English class	06.04.2020	1,0	
LCA	06.04.2020	2,0	Try to understand e-mail mats & niklas, think about solutions for the energy problem, discussing with Dorien
Swedish class	06.04.2020	1,5	Watch Swedish videos & do exercises
Wood tutorial	06.04.2020	1,0	Reading
Individual Meeting with Shiva	07.04.2020	0,5	Discussing peer evaluation
Wood tutorial	07.04.2020	1,0	Reading
Meeting	08.04.2020	3,5	Modelling in SimaPro
E-mails	08.04.2020	1,5	Writing e-mails to Mats & Niklas
Meeting	09.04.2020	3,0	Modelling in SimaPro
E-mail	09.04.2020	1,0	Writing e-mail to Mats
Swedish Homework	10.04.2020	1,0	
English exercises	12.04.2020	1,0	
English class	13.04.2020	2,5	Cultural presentations
Research secondary target	13.04.2020	2,0	
Research secondary target	14.04.2020	1,5	
Final report	16.04.2020	2,0	Starting chapter: research second target
Meeting	17.04.2020	1,5	Planning
Swedish class	17.04.2020	1,0	Watching Swedish videos & do exercises
Final report	18.04.2020	2,0	Writing chapter: research & scope (second target)
Final report	19.04.2020	3,0	Writing chapter: research & scope (second target)
English exercises	19.04.2020	2,0	Doing exercises & checking answers
SimaPro	19.04.2020	0,5	Understanding e-mail from Niklas & reading chapter in tutorial
Final report	20.04.2020	1,0	Further research about LCA
Swedish class	20.04.2020	1,0	
Final report	21.04.2020	2,5	Further research about LCA & writing chapter LCA
Calculation energy	21.04.2020	1,5	Understanding Mats e-mail & calculating energy
Meeting	22.04.2020	3,0	Continuing with Modelling, doing calculations, planning
Final report	22.04.2020	1,5	Writing chapter "data collection" (LCA)
Final report	23.04.2020	1,5	Writing chapter "data collection" (LCA)
Meeting	24.04.2020	2,0	Meeting with Shiva
English exercises	25.04.2020	3,0	
Final report	26.04.2020	0,5	Searching for LCA reports & reading
Final report	28.04.2020	1,0	Searching for LCA reports & reading

Final report	29.04.2020	2,5	Research LCA, reading, writing
Meeting	29.04.2020	2,5	
Final report	29.04.2020	1,0	Research, writing about methods and impact categories
Final report	30.04.2020	4,0	Writing about midpoint and endpoint, categories, structure my references
English Exam	30.04.2020	1,0	
Meeting	01.05.2020	1,5	
Final report	01.05.2020	4,0	Writing my texts, structuring report, structure my references
English Exam	03.05.2020	1,5	
English Exam	04.05.2020	3,0	
Meeting	05.05.2020	1,0	
Final report	05.05.2020	2,0	Explaining categories and equivalents, doing some changes in my texts
Final report	06.05.2020	2,0	Writing about data (assumptions etc.), finishing my texts, adding ideas and comments for missing information
Final report	07.05.2020	4,0	Writing, reading, commenting
Final report	08.05.2020	4,0	Writing conclusion first target, reading, commenting
Final report	09.05.2020	2,0	Discussing with Dorien what still needs to be done & checking report
Final report	10.05.2020	4,5	Rewriting my chapter 2.2.3, rewriting, reading
Final report	11.05.2020	9,0	Rewriting, checking and writing about calculations, creating screenshots of all networks, starting with figures etc.
Meeting	12.05.2020	1,5	Discussing final report, ppt and video
Final report	12.05.2020	3,0	Rewriting texts, references & tables, searching input for the video
Final report	13.05.2020	7,0	Rewriting, clarifying comments, rewriting calculation, creating final document with pictures etc.
Final report	14.05.2020	5,0	Writing introduction & conclusion, rewriting, checking comments
Meeting	14.05.2020	1,5	Discussing final report, ppt and video
Final report	14.05.2020	4,0	Rewriting lessons learned, reading, numbering all figures & tables
Final report	15.05.2020	3,0	Reading, make last changes
Meeting	15.05.2020	1,5	Presentation, who does what
Presentation	15.05.2020	4,0	Thinking about my content, preparing my texts & improving my slides
Meeting	16.05.2020	2,0	Practise presentation
Presentation	16.05.2020	3,0	Improving my texts
Meeting	17.05.2020	2,0	Practise presentation
Presentation	17.05.2020	3,0	Corrections, practise
Final presentation	18.05.2020	4,5	Final presentations

Dorien Saliën

Kind of work	Date	Hours	Comments	Total Time 291,5
PM class	05.02.2020	1,5		
Team building	07.02.2020	1,5		
Team meeting	07.02.2020	1,5		
Simapro Coffee tutorial	07.02.2020	1,0	First experience with SimaPro	
Brainstorm	08.02.2020	1,5	Brainstorm about the project	
PM class	10.02.2020	1,5		
Swedish class	10.02.2020	1,5		
Simapro Wood tutorial	10.02.2020	1,5	Stuck at adding transport	
English class	11.02.2020	1,5		
English homework	12.02.2020	2,5	Presentation article	
English class	13.02.2020	1,5		
Team meeting with Mirka	14.02.2020	2,0	Everything got cleared out about the project	
Simapro Wood tutorial	14.02.2020	2,0	Solved transportStuck at chart (wood is missing)	
PM homework	15.02.2020	3,0	Preparing presentation	
PM homework	15.02.2020	0,5	Doing Belbin test	
PM class	17.02.2020	1,5		
Swedish class	17.02.2020	1,5		
			Doing the social group contract	
Team meeting	17.02.2020	1,5	getting the Roles in Team	
Simapro meeting with Niklas	17.02.2020	1,0	Asking questions, getting answers	
			Search information about sanding discs	
Information process	20.02.2020	3,0	Added a few things to the 'relevant data' sheet	
			Started risk analyse add information to timeline	
Risk analyse Timeline Responsibilities	24.02.2020	2,0	divide tasks	
Fixing timetable (home)	24.02.2020	0,5	Fixing my timetable	
English homework	24.02.2020	3,0	Article: This is Finland	
Swedish homework	25.02.2020	1,5	Exercise 1, 3 and 4	
			Meeting at Mirka with Mats	
			(tour through production and discussing the	
Meeting Mirka	27.02.2020	3,0	questions)	
English class	09.03.2020	1,5		
PM class	09.03.2020	1,5		
Swedish class	09.03.2020	1,5		
Team meeting	09.03.2020	1,5	See minutes document	
Swedish homework	10.03.2020	2,0	Study for test	
Swedish class	11.03.2020	1,5		
English class	11.03.2020	1,5		
Team meeting	11.03.2020	1,0	SimaPro	
Writing mid term	12.03.2020	2,5	EPS, team, Belbin	
Writing mid term	12.03.2020	2,0	How sanding paper is made	
Secondary target	12.03.2020	2,0	Research + preparing tomorrows meeting	
Team meeting	13.03.2020	2,5		
Writing mid term	14.03.2020	3,0	Primary target + reading	
Writing mid term	15.03.2020	4,5	Primary target + reading	
PM class	16.03.2020	1,5		
Team meeting	16.03.2020	1,5		
Swedish class	16.03.2020	1,5		
Team meeting	17.03.2020	1,5		
Midterm	18.03.2020	0,5	Planning	
Discord meeting	19.03.2020	1,0	Discuss planning	
Discord meeting	20.03.2020	1,0	RACI matrix	
Mid term report	20.03.2020	3,0	Reading, making flow hart, checking comments	
Mid term report	21.03.2020	2,0	Reading, commenting, adding text	
Mid term report	22.03.2020	4,0	Reading, commenting, correcting, adding text	
Mid term report	23.03.2020	3,0	Reading, commenting, correcting	
Mid term report	24.03.2020	4,0	Reading, commenting, correcting	
Team meeting	25.04.2020	1,0	Getting to know MC Teams, discuss presentation	
Mid term report	25.03.2020	8,0	Styling and restructuring midterm report	
Mid term report	26.03.2020	2,0	Minor changes and fixing mistakes	
Mid term report	27.03.2020	3,5	Reading, checking, correcting	
Mid term presentation	28.03.2020	0,5	Improving my slides	
Team meeting	29.03.2020	1,0	Discuss presentation	
Mid term presentation	29.03.2020	3,0	Write text and practise text	
English homework	29.03.2020	2,5	Exercises on academic writing	
Mid term presentations	30.03.2020	4,5	Presenting midterm report	
Swedish homework	31.03.2020	2,0	Swedish class + write about family	
			Comments midterm, peer evaluations, what to do	
Team meeting	01.04.2020	1,5	next	

Peer evaluation	01.04.2020	2,0	Writing peer evaluation
Group meeting SimaPro	02.04.2020	3,0	Modelling
Group meeting SimaPro	03.04.2020	1,5	Modelling
Email	03.04.2020	1,0	Help Claudia with emailing Mats
English class	06.04.2020	1,0	
			Try to understand mail mats & niklas Think about solutions for the energy problem
LCA	06.04.2020	2,0	Discussing with Claudia
Wood tutorial	06.04.2020	2,0	Rereading
Meeting Shiva	07.04.2020	0,5	Discussing peer evaluation
Wood tutorial	07.04.2020	2,5	Rereading and adding missing parts
Group meeting SimaPro	08.04.2020	3,5	
Email Mats	08.04.2020	1,0	Help Claudia with writing an email to Mats
Group meeting SimaPro	09.04.2020	3,0	
Email Mats	09.04.2020	0,5	Help Claudia with writing an email to Mats
Swedish homework	12.04.2020	2,5	
English presentation	12.04.2020	1,0	
English class	13.04.2020	2,5	Cultural presentations
Project	13.04.2020	1,5	Did some reading + planning
Team meeting	15.04.2020	3,5	See minutes document
LCA	15.04.2020	1,5	Creating document with values
Swedish	16.04.2020	1,0	
LCA	16.04.2020	2,5	Finishing document with values
Swedish	16.04.2020	3,0	Studying
Team meeting	17.04.2020	1,5	Planning
Swedish class	21.04.2020	2,0	
Team meeting	22.04.2020	3,0	
English exercises	23.04.2020	3,5	Academic writing exercises
Meeting Shiva	24.04.2020	2,0	
Team meeting	27.04.2020	3,5	
English exercises	27.04.2020	3,0	Academic writing exercises
LCA report	28.04.2020	1,0	Searching LCA reports for reference
Team meeting with Niklas	29.04.2020	2,5	
Final report	30.04.2020	4,0	Writing
Meeting Shiva	01.05.2020	1,5	
English exam	02.05.2020	1,5	
English exam	03.05.2020	1,5	
English exam	04.05.2020	4,0	
Meeting Shiva	05.05.2020	1,0	Discussing first draft of final report
Final report	05.05.2020	4,0	Reading, research, writing
Final report	06.05.2020	3,0	Reading, commenting
Final report	07.05.2020	5,5	Reading, commenting, research, writing
Final report	08.05.2020	5,0	Reading, commenting, writing
Final report	09.05.2020	2,0	Discussing with Claudia what still needs to be done
Final report	09.05.2020	4,0	Reading, rewriting
Final report	10.05.2020	5,5	Reading, rewriting
Final report	11.05.2020	6,0	Reading, rewriting, proof reading my rewritten texts
Meeting Shiva	12.05.2020	1,5	Discussing final report, ppt and video
Final report	12.05.2020	7,0	Reading, checking, fixing comments, starting design
Final report	13.05.2020	7,0	Reading, checking, fixing comments, design, draw charts
Meeting Shiva	14.05.2020	1,5	Discussing final report, ppt and video
Final report	14.05.2020	12,0	Finishing design
Final report	15.05.2020	4,0	Make last changes
Team meeting	15.05.2020	1,5	Presentation, who does what
Presentation	15.05.2020	4,0	Writing text
Team meeting	16.05.2020	2,0	Practise presentation
Presentation	16.05.2020	3,0	Rewrite text where necessary, practise text
Team meeting	17.05.2020	2,0	Practise presentation
Presentation	17.05.2020	3,0	Practise text
Final presentation	18.05.2020	4,5	Final presentations

Marcos Parrado

Kind of work	Date	Hours	Comments	Total Time 246,5
PM class	05.02.2020	1,5		
Team building	07.02.2020	1,5		
Team meeting	07.02.2020	1,5		
Simapro Coffee tutorial	07.02.2020	1,5	First experience with SimaPro	
PM class	10.02.2020	1,5		
Swedish class	10.02.2020	1,5		
Swedish homework	10.02.2020	2,0		
Simapro Wood tutorial	10.02.2020	1,5	Stuck at adding transport	
English class	11.02.2020	1,5		
English homework's	13.02.2020	2,0	Presentation	
English class	13.02.2020	1,5		
Team meeting with Mirka	14.02.2020	2,0	Everything got cleared out about the project	
English class	14.02.2020	1,5		
PM presentation & Belbin	16.02.2020	2,5	Preparing presentation and complete Belbin test	
PM class	17.02.2020	1,5		
Team meeting	17.02.2020	1,5	Doing the social group contact getting the Roles in Team	
Simapro meeting with Niklas	17.02.2020	1,5	Asking questions, getting answer	
SimaPro Wood Tutorial	17.02.2020	1,5	Learn how SimaPro works	
Information process	19.02.2020	2,5	Look for information about the process	
Risk analyse, timeline, responsibilities	24.02.2020	2,5	Started risk analyse, add information to timeline, divide tasks	
English homework's	24.02.2020	2,5	Culture text	
Swedish homework's	24.02.2020	2,5		
LCA & SIMAPRO	25.02.2020	3,0	Writing report of LCA & SimpaPro	
Being updated & Writing	06.03.2020	2,0	Writing for midterm and reading mirka input mails	
PM class	09.03.2020	1,5		
Swedish class	09.03.2020	1,5		
English class	09.03.2020	1,5		
Team meeting	09.03.2020	2,0	Meeting with the team and Shiva	
Swedish study	10.03.2020	2,0	Study Swedish for the exam	
Swedish class	11.03.2020	1,5		
English class	11.03.2020	1,5		
Group meeting	11.03.2020	1,0	Group meeting working with simapro	
Research & writing	11.03.2020	3,0	Research and writing about the secondary task	
Swedish homework's	12.03.2020	2,0	HomeWorks	
Team meeting	13.03.2020	2,5		
Mid Term writing	14.03.2020	3,0	Writing for mid term	
Mid Term writing	15.03.2020	2,5	Write and review mid term	
Team meeting	17.03.2020	1,5		
Team meeting	19.03.2020	1,0		
Meeting document	20.03.2020	0,5	Prepare the 16.03 meeting documentation	
Writing for midterm	21.03.2020	3,0		
Reading & correcting mistakes from mid term	22.03.2020	2,5	Rewriting midterm	
English & Swedish homework	23.03.2020	3,5		
Swedish online lesson and homework	24.03.2020	3,0		
Teams meeting	25.03.2020	1,5	Learn about teams and talk about mid term	
Swedish writing	25.03.2020	3,0	Writing about family	
Prepare mid term presentation	26.03.2020	3,0	Power point presentation	
Mid term presentation	27.03.2020	2,5	PP presentation	
Swedish homework	27.03.2020	1,5		
English exercises	27.03.2020	2,0		
Presentation	28.03.2020	3,0		
Prepare the presentation & PP	29.03.2020	2,0		
Group meeting	29.03.2020	1,0	Group meeting about mid term	
Mid term presentation	30.03.2020	4,5		
Peer evaluation	01.04.2020	1,0	Peer evaluation after mid term	
Team meeting	01.04.2020	1,5	Team meeting to talk about the mid term and the next steps of the project	
Swedish exercises and lesson	01.04.2020	1,5	Food, drinks and clock	
TBSC & LCA boundaries	01.04.2020	1,5	Writing trying to fix the problems that we had in the mid term in some writing points	
Simapro meeting	02.04.2020	3,0		
SimaPro meeting	03.04.2020	1,5		
English class	06.04.2020	1,0	Introduction to formal writing	
Writing TBSC	07.04.2020	2,0	Writing about TBSC and his role in our project	
Wood tutorial	07.04.2020	2,0	Reading again	
Peer evaluation with Shiva	07.04.2020	0,5		

Team meeting	08.04.2020	3,5	
Team meeting	09.04.2020	3,0	
Research task two	10.04.2020	2,0	New ideas for task two
English exercises	11.04.2020	1,5	
English presentation	12.04.2020	2,0	Prepare English presentation
English class	13.04.2020	2,5	Cultural presentation
Swedish homework	14.04.2020	2,0	Swedish homework and study vocabulary
Research second task	14.04.2020	1,0	
TBSC & LCA boundaries	14.04.2020	0,5	Rewriting
Team meeting	15.04.2020	3,5	
Second task writing	16.04.2020	3,0	
Team meeting	17.04.2020	1,5	Planning next week
Swedish class	17.04.2020	1,0	
Writing for final report	18.04.2020	2,5	Writing 3.1 introduction and brainstorm
Study Swedish	18.04.2020	2,0	Study for the Swedish exam
Niklas info	20.04.2020	2,0	Looking for info about what nicklas said
Swedish lesson	20.04.2020	1,0	
Group meeting	22.04.2020	3,0	
Writing final report	23.04.2020	3,0	
Group meeting	24.04.2020	2,0	
Writing final report	25.04.2020	2,5	How SimaPro works text
Writing final report	26.04.2020	3,0	
Team meeting	27.04.2020	3,5	Organize the weeks to come
English Exercises	28.04.2020	3,0	Formal English exercises
Team meeting with Nicklas	29.04.2020	2,5	Meeting with Nicklas talking about SimaPro results
English Exercises	29.04.2020	2,5	Finish academic English exercises
Reading LCA examples	30.04.2020	2,5	Research about how to write an LCA report
Final report writing	30.04.2020	1,5	Writing the final report
Meeting	01.05.2020	1,5	
English exam	03.05.2020	2,5	Second part of the English exam
Meeting with Shiva	05.05.2020	1,5	Team meeting for organize the last week
Reading LCA reports	05.05.2020	2,5	Research about how to write our final report
Rewriting Final report	05.05.2020	3,0	Writing in a formal way the final report
Rewriting Final report	05.06.2020	2,5	Writing in a formal way the final report
Rewriting Final report	07.05.2020	2,5	Reading my teams comments and correcting my mistakes
Writing final report	07.05.2020	2,5	Writing about system boundaries and the new midpoint created
Writing final report	08.05.2020	2,5	Writing about avoided energy & materials on SimaPro
Correcting mistakes	08.05.2020	2,0	References & reading the feedback of the team
Presentation	09.05.2020	2,0	Creating concept and organizing the content
Presentation	10.05.2020	2,5	Developing presentation
Presentation	11.05.2020	2,5	Developing presentation
Meeting with Shiva	12.05.2020	1,5	Talking about final report
Presentation	12.05.2020	3,0	Applying changes based on feedback
Presentation	13.05.2020	3,0	Continue with the final presentation
Presentation	14.05.2020	2,5	
Team Meeting	14.05.2020	1,5	Last things of report to talk about
Presentation	15.05.2020	2,5	Finishing presentation
Reading final report	15.05.2020	1,5	
Writing text for presentation	15.05.2020	2,0	
Meeting presentation	15.05.2020	1,5	
Practise group presentation	16.05.2020	2,0	
Practise presentation	17.05.2020	3,0	
Final presentation	18.05.2020	4,5	

Marvin Hofmann

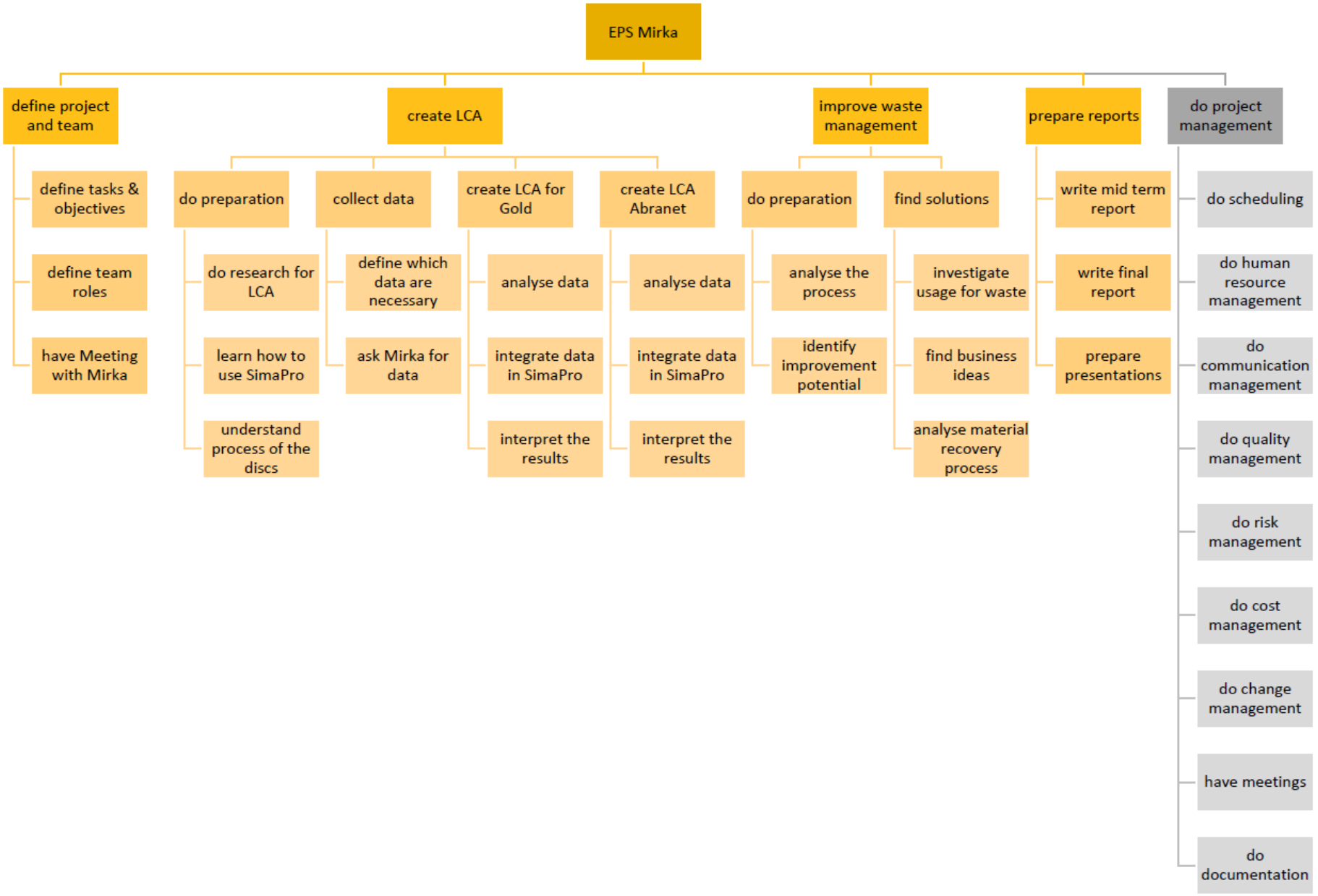
Kind of work	Date	Hours	Comments	Total Time 255,5
PM class	05.02.2020	1,5		
Team building	07.02.2020	1,5		
Team meeting	07.02.2020	1,5		
Simapro Coffee tutorial	07.02.2020	1,0	First experience with SimaPro	
Brainstorming about the project	08.02.2020	1,5		
PM class	10.02.2020	1,5		
Swedish class	10.02.2020	1,5		
Simapro Wood tutorial	10.02.2020	1,5	Stuck at adding transport	
English class	11.02.2020	1,5		
English homework	12.02.2020	2,0	Presentation article	
English class	13.02.2020	1,5		
Team meeting with Mirka	14.02.2020	2,0	Everything got cleared out about the project	
Simapro Wood tutorial	14.02.2020	2,0	Solved transport stuck at chart (wood is missing)	
Do Belbin test	15.02.2020	2,5		
PM homework	15.02.2020	4,5	Preparing presentation	
PM class	17.02.2020	1,5		
Swedish class	17.02.2020	1,5		
Team meeting	17.02.2020	1,5	Doing the social group contact getting the Roles in Team	
Simapro meeting with Niklas	17.02.2020	1,0	Asking questions, getting answer	
Research	18.02.2020	3,0	About task No.2	
Information process	19.02.2020	3,0	Search information about sanding discs Added a few things to the 'relevant data' sheet	
English homework	24.02.2020	3,0	Article: This is Finland	
Fixing my timetable	24.02.2020	0,5		
Meeting Mirka	27.02.2020	3,0	Meeting at Mirka with Mats (tour through production and discussing the questions)	
Swedish homework	08.03.2020	2,0	Learning for the test	
PM class	09.03.2020	1,5		
Swedish class	09.03.2020	1,5		
Team meeting	09.03.2020	1,5	See minutes document	
Swedish homework	10.03.2020	2,0	Exercise 1,3,4	
Swedish class	11.03.2020	1,5		
English class	11.03.2020	1,5		
Team meeting	11.03.2020	1,0	SimaPro	
Preparing next meeting	12.03.2020	1,0		
Recycle sanding disk	12.03.2020	3,0	Research	
Team meeting	13.03.2020	2,5		
Mid term report	14.03.2020	3,5	Cost management	
Mid term report	15.03.2020	4,0	Intro quality management	
Mid term report	16.03.2020	2,0	Quality management	
PM class	16.03.2020	1,5	Quality management	
Team meeting	16.03.2020	1,5		
Swedish class	16.03.2020	1,5		
Team meeting	17.03.2020	2,0		
Discord meeting	19.03.2020	1,0		
Mid term report	19.03.2020	1,0	Discuss planning	
Discord meeting	20.03.2020	1,0	Writing	
Mid term report	21.03.2020	1,5	RACI matrix	
Mid term report	22.03.2020	2,0	Writing	
Mid term report	23.03.2020	2,0	Correcting, finding new info	
Mid term presentation	24.03.2020	1,0	Correcting, finding new info	
Teams meeting	25.03.2020	1,0	First experience with Teams	
Working on presentation	25.03.2020	2,0	New presentation	
Working on presentation	26.03.2020	0,5	Correcting, finding new info	
English I	26.03.2020	1,0	Reading for the presentation	
Swedish lesson	27.03.2020	1,5	Videos and exercises	
Final presentation	27.03.2020	2,5	Final the presentation	
Reading final report	27.03.2020	0,5	Correction reading	
Teams meeting	29.03.2020	1,5	Final the presentation	
Working on presentation	29.03.2020	1,5	Correction mistakes on presentation	
Mid term presentation	30.03.2020	4,5		
English presentation	31.03.2020	0,5	Doing the presentation	
Swedish homework	31.03.2020	1,0	Text about my family	
Team meeting	01.04.2020	1,5		
Peer evolution	01.04.2020	1,0		
Research	02.04.2020	1,0	Distance	
Meeting Mirka	02.04.2020	3,0	Starting LCA	
Meeting Mirka	03.04.2020	1,5	Going on with the LCA	
Swedish	05.04.2020	1,5	Learning vocabulary	
English Class	06.04.2020	1,0	Introduction formal writing	

Swedish	07.04.2020	1,5	Vocabulary, grammar
Peer evolution	07.04.2020	0,5	Discuss with Shiva
Wood tutorial	07.04.2020	1,0	Rereading
Research	08.04.2020	1,0	Co2 emissions
Team meeting	08.04.2020	3,5	
Research	09.04.2020	1,5	Task two
Meeting	09.04.2020	3,0	Working in LCA
Research	09.04.2020	1,5	New distance
English presentation	13.04.2020	1,5	Research
English cultural final presentation	13.04.2020	2,5	
Learning Swedish	13.04.2020	1,5	Vocabulary
Starting calculation	13.04.2020	2,0	
Preparing next meeting	13.04.2020	0,5	
Meeting Mirka	15.04.2020	3,5	
Research	15.04.2020	1,5	How to write an LCA
Research	15.04.2020	2,5	Calculation+ distance
Research	16.04.2020	1,5	Calculation+ distance
Teams meeting	17.04.2020	1,5	
Study Swedish	18.04.2020	1,0	
Earned Value analyse	19.04.2020	2,0	Brainstorming, getting ideas
Writing final report	20.04.2020	1,0	
Swedish lesson	20.04.2020	1,0	
English exercise	21.04.2020	2,0	Starting academic writing
Writing final report	21.04.2020	2,0	
Meeting Mirka	22.04.2020	3,0	Continuing with Modelling, doing calculations, planning
Update the file	23.04.2020	2,0	Calculation/values
Update earned value	23.04.2020	0,5	Including contact to roger
Meeting	24.04.2020	2,0	
English exercise	25.04.2020	5,0	
Research	26.04.2020	2,5	New distance, new calculation
Research	27.04.2020	1,5	New distance, new calculation
Team meeting	28.04.2020	3,5	Finish the LCA
English exam	29.04.2020	2,5	
Final report	29.04.2020	2,0	EVA
Team meeting with Niklas	29.04.2020	2,5	
Final report	30.04.2020	3,0	Writing about calculation finish the file
Final report	01.05.2020	2,5	EVA , help from Stefan
Team meeting	01.05.2020	1,5	
Final report	01.05.2020	3,0	Writing tree part, copy into drive document
English exam	02.05.2020	2,5	
Meeting	05.05.2020	1,0	
Final report	05.05.2020	1,5	Rewriting
Final report	06.05.2020	4,0	Rewriting / finishing tree/ working on EVA
Fina report	07.05.2020	3,0	
Final report	08.05.2020	4,0	Writing, reading, rewriting
final report	09.05.2020	3,0	Writing
Final report	10.05.2020	3,0	Rewriting
Fina report	10.05.2020	0,5	Checking the presentation
Final report	10.05.2020	3,0	Rewriting, reading presentation, continue EVA, reading
Meeting	10.05.2020	1,5	
Final report	12.05.2020	3,5	Rewriting EVA, reading report, research picture
Final report	12.05.2020	1,5	
Video	12.05.2020	2,0	Searching for pictures and ideas
Final report	14.05.2020	3,0	Writing and reding acknowledgment, EVA, fixing time table
Team meeting	14.05.2020	1,5	
finarl report	15.05.2020	2,0	fixing table and EVA, taking screenshots
Video	15.05.2020	1,0	Write an idea sheet for the video
Final presentation	15.05.2020	0,5	
Team meeting	15.05.2020	1,5	Presentation, who does what
Presentation	15.05.2020	4,0	Writing text
Team meeting	16.05.2020	2,0	Practise presentation
Presentation	16.05.2020	2,0	Practise text
Team meeting	17.05.2020	1,5	Practise presentation
Presentation	17.05.2020	1,5	Practise text
Final presentation	18.05.2020	4,5	Final presentations

Appendix J4: Work breakdown structure

The work breakdown structure (WBS) shows all tasks that must be completed within the project. The input for the WBS are the objectives that were defined. After defining these objectives, which are based on the information given by TBSC and Mirka, the tasks were listed with the help of a decomposition of the goals and objectives. Afterwards the tasks were organized in a WBS, which is the output of this project management part and will be used for the next step project time management.

The appendix A shows that first the project as well as the team roles will be defined. Furthermore, all tasks that are necessary to create the LCA are listed under “create LCA”. The tasks for the secondary target are shown under “improve waste management”. Furthermore, the team must prepare a midterm report, a final report and presentations. Besides these tasks, which will be included in a schedule, there is also a path for project management. The colour is grey to make it clear that this part will not appear in the schedule. This is because the tasks for project management run parallel to all other tasks.

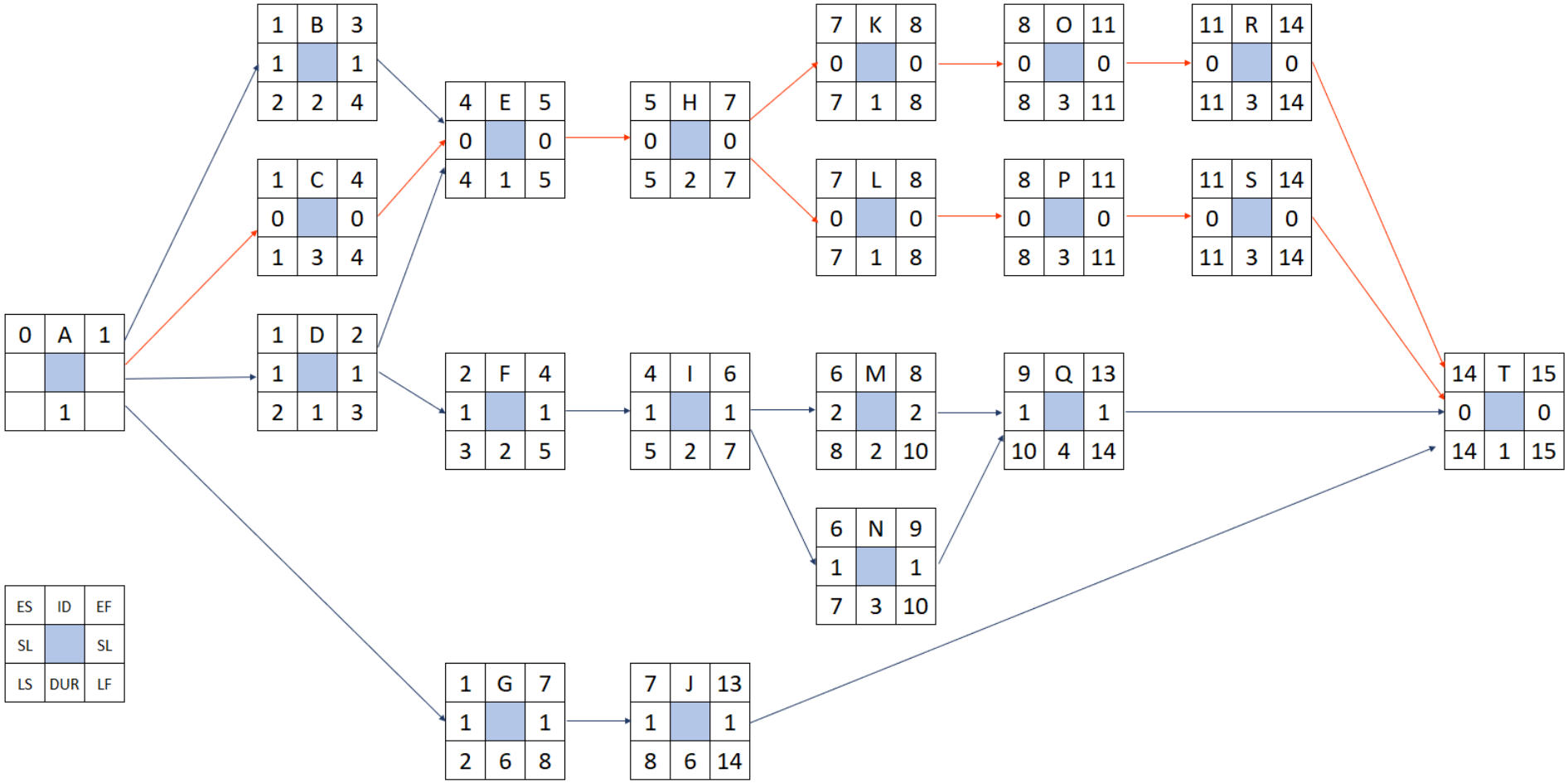

EPS Mirka
define project and team
define tasks & objectives
define team roles
have Meeting with Mirka
create LCA
do preparation
do research for LCA
learn how to use SimaPro
understand process of the discs
collect data
define which data are necessary
ask Mirka for data
create LCA for Gold
analyse data
integrate data in SimaPro
interpret the results
create LCA Abranet
analyse data
integrate data in SimaPro
interpret the results
improve waste management
do preparation
analyse the process
identify improvement potential
find solutions
investigate usage for waste
find business ideas
analyse material recovery process
prepare reports
write mid term report
write final report
prepare presentations
do project management
do scheduling
do human resource management
do communication management
do quality management
do risk management
do cost management
do change management
have meetings
do documentation

Appendix J5: Project time management

The input for the project time management is the WBS from chapter 4.1. All activities from the WBS were sequenced in an arrow chart, first by hand and afterwards in Excel. In this chart also the durations were estimated. Based on the durations, the dates of start and finish were specified. With the help of the arrow chart, the critical path can be identified. Therefore, the project team should focus on the path “create LCA”, because there are no slacks between the tasks. Based on the arrow chart, the project team created a bar chart. Besides the time, also the responsible persons are defined. Additionally, milestones are created. The duration of a milestone is 0. You can recognize a milestone by the following symbol: 

In the bar chart you can also see the status of each activity (finished, in process, not started or delayed). For the scheduling no specific tool was used, but the charts were created manually in excel.

The output of the project time management is the project schedule, which includes the durations, the start and end dates and the responsible persons for all activities and which is used for the following chapter.


ES ID EF
SL SL
LS DUR LF
0 A 1
1
1 B 3
1 1
2 2 4
1 C 4
0 0
1 3 4
1 D 2
1 1
2 1 3
4 E 5
0 0
4 1 5
2 F 4
1 1
3 2 5
1 G 7
1 1
2 6 8
5 H 7
0 0
5 2 7
4 I 6
1 1
5 2 7
7 K 8
0 0
7 1 8
7 L 8
0 0
7 1 8
6 M 8
2 2
8 2 10
6 N 9
1 1
7 3 10
8 O 11
0 0
8 3 11
8 P 11
0 0
8 3 11
9 Q 13
1 1
10 4 14
7 J 13
1 1
8 6 14
11 R 14
0 0
11 3 14
11 S 14
0 0
11 3 14
14 T 15
0 0
14 1 15

A define tasks, objectives and team roles

B do research for LCA

C learn how to use SimaPro

D understand process of the discs

E define which data are necessary

F analyse the process

G write mid term report

H collect data from Mirka

I identify improvement potential

J write final report

K analyse data Gold

L analyse data Abranet

M investigate usage for waste

N analyse material recovery process

O integrate data in SimaPro Gold

P integrate SimaPro Abranet

Q find business ideas

R interpret the results

S interpret the results

T finish final report & prepare presentations

Appendix J6: Project human resource management

The input for the human resource management is the WBS.

This part of the project management involves how to organize and manage the project inside the team. Each team member has specific skills, and the responsibilities that are assigned to each person must be given in relation to them.

In this project, there is a supervisor who will be the responsible of this work and the one who will set the quality metrics. There is also a group leader or project manager, Dorien who will solve possible problems that can be generated during the project and must lead the team at key moments. Although this does not mean that the rest of the team members have no responsibility for the result of the project.

For the assignment of the responsibilities for each task, it has been decided to use a well-known methodology. This methodology is known as a RACI matrix and is one of the most simple and effective approaches to the definition and documentation of the project roles.

The RACI matrix assigns who is responsible (R) for each action, which person is accountable (A) and who needs to be consulted (C) or informed (I). (Kantor)

The project has been divided in five different chapters, and these chapters have been divided into simpler tasks that can be assigned to one or two people following the WBS.

The output of this chapter is the RACI Matrix, which is shown in Table 1.

	Dorien	Marvin	Claudia	Marcos	Shiva
Define project and the team					
Define tasks & objectives	R	A	A	A	C
Define team roles	R	A	A	A	I
Create LCA					
Research about LCA	A	A	A	R	I
Learn about SimaPro	A	A	A	R	C
Understand the productions of sanding disc	R	A	A	A	C
Define necessary data and ask Mirka	A	A	R	A	C
Modelling LCA for Gold	R	C	C	A	C
Modelling LCA for Abranet	R	C	C	A	C
Improve waste management					
Brainstorm for possible solutions	A	R	A	A	C
Make writing about the ideas	I	I	I	R	I
Business ideas	C	R	A	C	I
Prepare reports					
Write midterm report	R	A	A	A	C
Write final report	A	A	R	A	C
Prepare presentations	A	A	A	R	I
Do project management					
Do scheduling	A	C	R	C	I
Do human resource management	A	A	A	R	I
Do communication management	A	A	R	C	C
Do quality management	I	R	I	I	I
Do risk management	A	C	R	A	I
Do cost management	I	R	I	I	I
Do change management	I	R	I	I	I
Do documentation	A	I	R	I	I

Appendix J7: Project cost management

Methods for the calculation of the costs

Working hours

One of the costs that need to be considered in a project are the working hours. These hours represent the amount of time the team will spend on the project. For the EPS project the following conditions are fixed:

- 4 team members
- 37.5 working hours per week
- Project duration: 15 weeks

These values are used to calculate the total working hours for the project:

*15 weeks * 37.5 hours / week * 4 = 2250 hours.*

To calculate the hourly wage, the average monthly income in Finland of 3079 € is used as a reference (Statistics Finland). Considering that a month has four weeks, the following costs are calculated:

3079 € / 4 weeks = 769.75 € / week
769.75 € / 37.5 hours = 20.53 € / hour.

Other costs

To understand the sanding disc manufacturing process, the team visited the company and was given a guided tour through the production line. The distance from Vaasa to Mirka was about 100 km (one way) with the car. The car takes about 10 l per 100 km and one liter of fuel costs 1.50 €.

Another cost is the program SimaPro. For the first year, a commercial license costs 9500 €.

Results

Category	Calculation	Cost
Working hours	2250 hours * 20.53 €/hour	46193 €
Software SimaPro	-	9500 €
Travel costs	10 l/100 km * 200 km * 1.50 €/l	30 €
Total Costs	-	**55723 €**

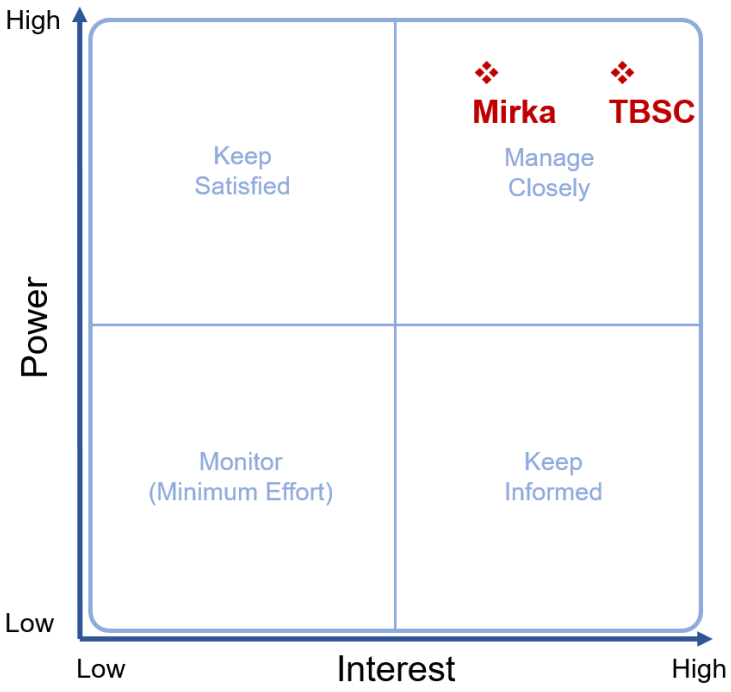
Table 2 shows the results of the cost management. The total cost for the entire project is 55723 €. It is important to note that these are theoretical costs since this project is done by students, but it gives an idea of how it could have been in real life.

After the project is done, the costs are not high. Only the employees, who update the LCA or make a new LCA for other products must be considered. Also, the SimaPro license needs to be renewed every year, which would be 2150 € for every additional year. These costs are not part of the calculation, because they do not affect the current project.

Appendix J8: Project communication management

Meetings with TBSC and Mirka were organised to identify the expectations of the stakeholders. With the help of a stakeholder analysis the stakeholders were defined and analysed.

One of the stakeholders of the project is TBSC as the owner of the project. The responsible persons from TBSC will evaluate the project and the work of the team. As shown in Figure 6, TBSC has a very high interest in the success of the project and a very high power. Another stakeholder is the company Mirka, which is the client of the project. Therefore, the team fulfils the wishes of the company, to the best of their abilities. The company has a high interest in the project and, as well as TBSC, a very high power.



The EPS team constantly communicates with the client Mirka and the company is updated frequently about the current status. The goal is that in the end, the team will deliver results which the company can continue to use. The main interest of the company Mirka is getting an insight in the simulation tool SimaPro, to see how the software works. They will investigate which software could be used in the future and which information they can get from the software. Mirka is also interested to get results for the LCA. Furthermore, with the second target of the project, the interest of the company is to get ideas for the usage of the waste. The communication with Mirka will be done in personal meetings as well as by e-mail and by telephone, if it is necessary.

Appendix J9: Project quality management

Quality management includes all activities and objectives to ensure the quality of the product and the process. It is an organizational system that is intended to ensure that goods, services and processes are executed according to the requirements. The aspects of economy, legislation, environment and customer requirements are considered. (Windolph)

The tasks of quality management include:

- Quality planning
- Quality control
- Quality inspection
- Quality improvement

As part of the project management, various steps were taken in order to maintain the quality of the project from start to finish. At the beginning of the project, the group created a schedule to make sure that the project will be finished on time. Each member takes responsibility and must respect the given deadlines.

When someone has a problem, the rest of the team will try to help this person out. Besides that, the team discusses all important matters during face to face meetings and decisions are made together. These meetings take place one to two times a week. In addition, the supervisor gets updated regularly on the latest events and proceedings of the project. All work is documented properly including the minutes of each meeting. The group discusses what each member has to do due to the next meeting.

In order to be able to control the quality of the individual tasks, the following procedure is followed. Before a task is considered done, the group and the supervisor discuss the result. When the result is accepted by everyone, the status in the timeline (appendix C) switches into “finished” and the task is completed.

Furthermore, to ensure a productive work environment, the team decided to make some team rules for the project. The rules were made to motivate the group members to work efficiently. The contract of the team can be found in appendix E.

Last of all, the communication between the team and Mirka is very important for the project, especially for the output of the LCA. The team needs to be clear about which input is necessary and the company should provide the input as detailed as possible to get the best results. In order to do this, clear communication is essential. Therefore, a lot of attention is paid to the email traffic with the company.

Appendix J10: Project risk management

The input for the risk management are the project scope, the activities and the quality and cost management. First the team did a brainstorming about all possible risks. Afterwards the probability and the impact of each risk was specified. Both got numbers from 1 to 10. A high probability means that it is very likely that the risk will come true. A high number indicates that the impact is very high if the risk occurs. After this rating, the risk level is calculated by multiplying the probability and the impact. The rating of the risks can be seen in Table 3.

Table 4 and Table 5 show the explanation of the ranking numbers. In addition, the team decided for each risk whether it could be mitigated or prevented. Furthermore, actions and preventive measures were defined.

Risk	Probability (1-10)	Impact (1-10)	Risk level (Probability x Impact)	Mitigated	Prevented
lack of input data from the company	8	9	72	x	
problems with SimaPro	9	7	63	x	
lack of knowledge (team, company)	8	7	56	x	
lack of time	6	6	36		x
bad planning	6	6	36		x
language barriers	5	7	35	x	
conflicts inside the team	7	5	35	x	
lack of communication with the company	4	7	28	x	
sickness	6	3	18	x	
lack of motivation	5	2	10		x
differences between cultures and studies	2	2	4	x	

Probability of Failure	Ranking
Very high: Persistent failure	10
	9
High: frequent failure	8
Moderate: Occasional failure	7
	6
	5
Low: Relatively few failure	4
	3
Remote: Failure is unlikely	2
	1

Impact	Ranking
Hazardous - without warning	10
Hazardous - with warning	9
Very high	8
High	7
Moderate	6
Low	5
Very low	4
Minor	3
Very minor	2
None	1

As shown in Table 3, the risks with the highest risk level are “lack of input data from the company”, “problems with SimaPro” and “lack of knowledge”. To prevent these risks, the following actions and preventive measures should be implemented:

Lack of input data:

- the team should communicate with the company Mirka and ask for all necessary information
- possible communication channels are face-to-face meetings, email, phone, conference calls and video conferences

Problems with SimaPro:

- the team can use tutorials
- besides that, there is a responsible person at Technobothnia who is very familiar with the program and can help

Lack of knowledge:

- the team should do research about:
    - production and processes at Mirka
    - materials
    - primary target (LCA and SimaPro)
    - secondary target

Appendix J11: Project change management

Many problems or inconsistencies can arise during the project.
For example, mistakes could be:

- wrong budgeting
- bad time management
- too extensive task area
- crisis from outside (for example the coronavirus)

The purpose of change management is to pick up a problem, analyse it and decide on a new scheduling as a group. Change management takes its data from project cost, project schedule, project roles and risk management. A reason for changing a task can be for example a planning error, a new idea or a suggestion that turns out to work better than the existing methods that are in use.

During the team meetings, the proposal is made, and the group decides together whether the proposal is suitable or inappropriate. If the change is accepted, the change should be documented.

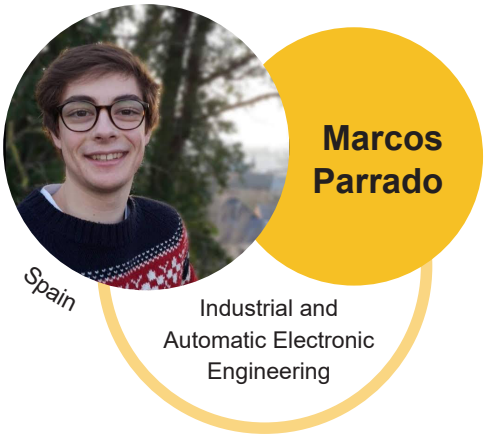
Changes in the current project:
The biggest change in this project happened because of the corona crisis.
The campus got closed, so there is no option for face to face meetings anymore.
Therefore, the team has switched from face to face meeting to weekly video conferences and communication via WhatsApp.

Another problem is that the program the team is supposed to use SimaPro to create the LCA is only available on the computers at the campus. Here, the supervisor helped out and found a solution. Now, the program can be used at home with the school license.

Furthermore, one of the team members decided to return home, because of the corona situation. This will affect the communication and the current way of working. Last of all, the deadline for this midterm report has changed, which means that the team has one more week to hand it in.

Appendix K: About the team

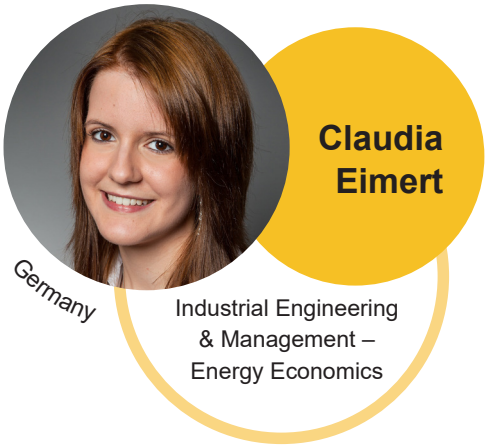
Appendix K1: Team members



Marcos Parrado

Spain

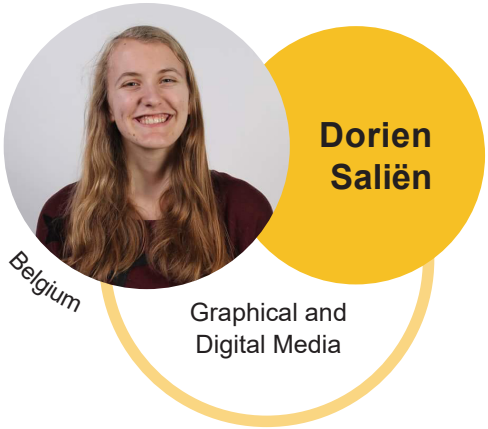
Industrial and Automatic Electronic Engineering



Claudia Eimert

Germany

Industrial Engineering & Management – Energy Economics



Dorien Saliën

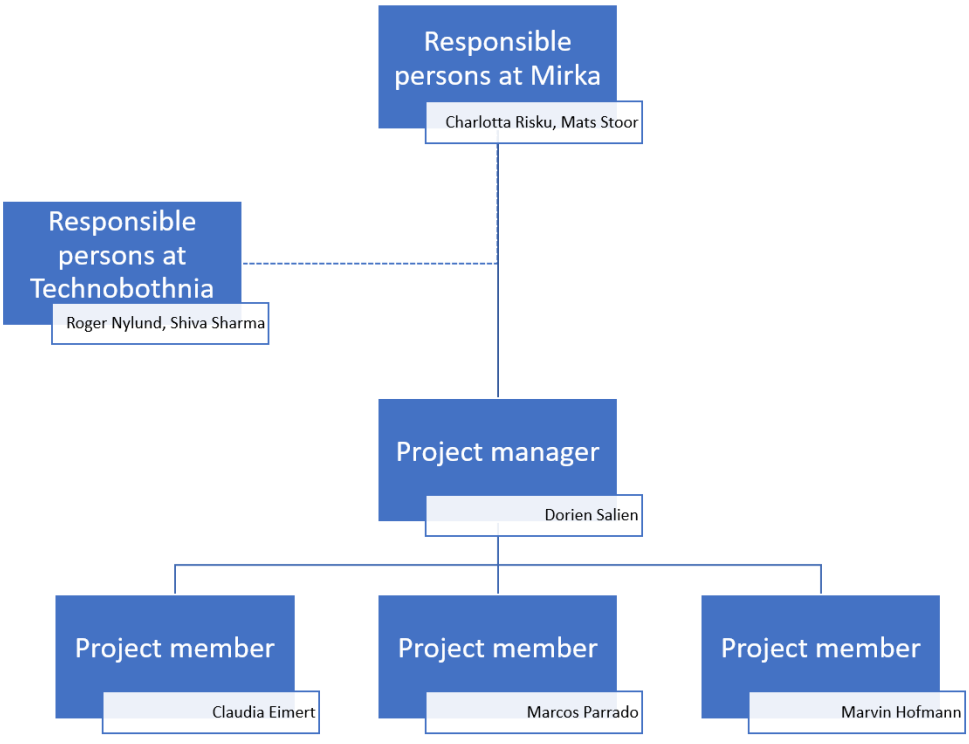
Belgium

Graphical and Digital Media

Marvin Hofmann

Germany

International Sales & Purchasing in Engineering



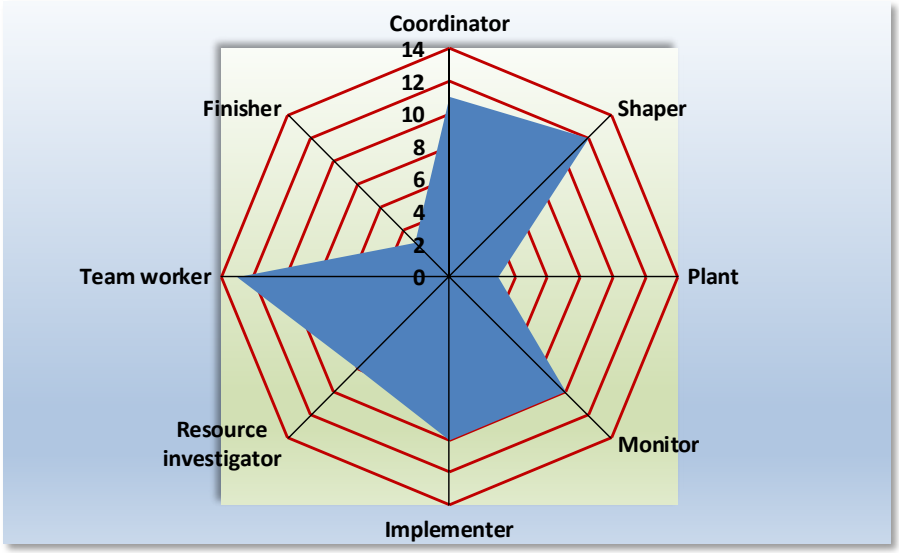
Appendix K2: Belbin roles

Introduction to the Belbin questionnaire

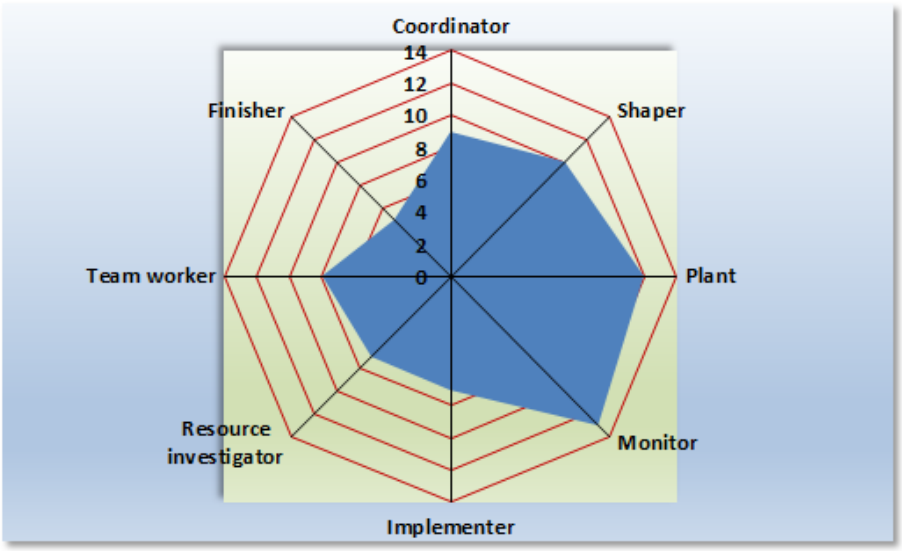
The foundation of a good functioning project team are project members with a different skill set. In this way, the members can help each other out on aspects that might be difficult for some, and easy for others. To find out what one member is good at and what he or she might be lacking, the Belbin questionnaire was developed. The result of this questionnaire is a so called ‘’role’’ within the team, which means that it describes the personality of each team member. If many members appear to have the same personality, the project might fail because some crucial skill assets could be missing.

5.2.2 Results of the questionnaire

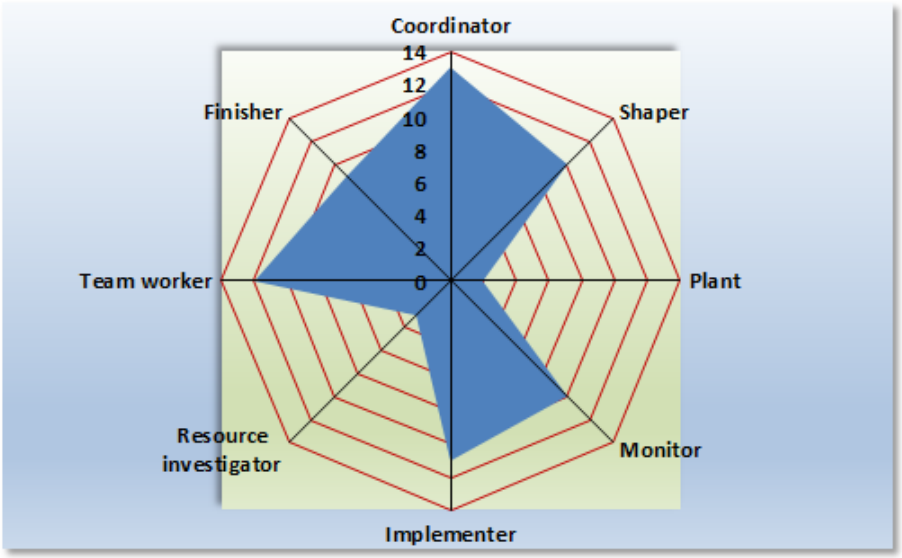
Dorien



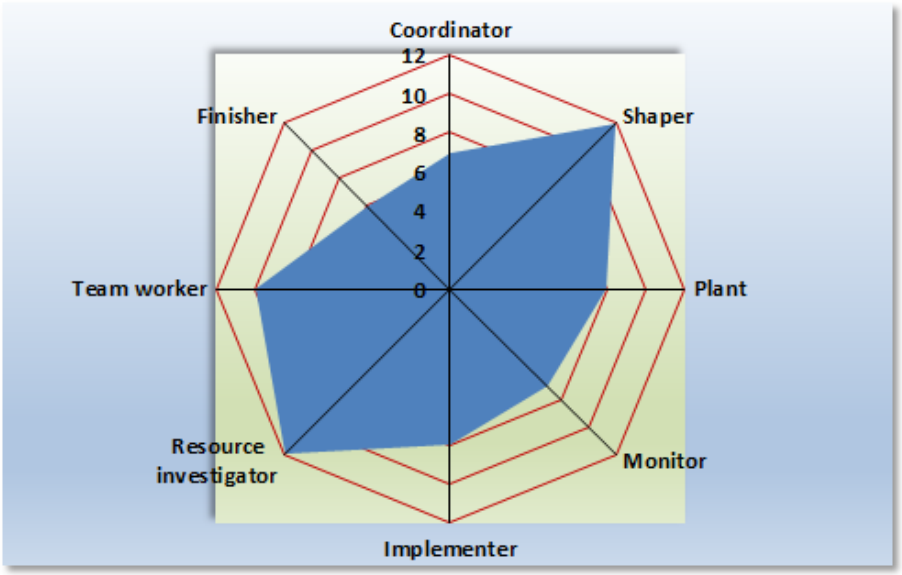
Marcos



Claudia



Marvin



Appendix L: Team contract

Starting document, 17.02.2020

Coach: Shiva

Project Members:

Name	Email	Phone
Dorien Saliën	dorien.salien@student.ap.be	+32472554292
Marvin Hofmann	Marvin.hofmann@student.fh-kiel.de	+491746051208
Marcos Parrado	Marcosparrado3@gmail.com	+34 638927875
Claudia Eimert	Claudia.eimert@hs-osnabrueck.de	+4915201057015

Agreements about:

1. Reaching each other (how do you contact each other and how quick do you need to respond?)

- As fast as possible, if you have read it you have to respond. Saying you will react to it later is also an respons, do tell when exactly (date and/or time).
- Via Whatsapp, mail and you could also call

2. What do we find important about documents that are handed in (before it is handed in officially)? What does it have to meet (think about language, lay-out etc.)?

- Do a language check by yourself before. After that you can also send it to Stephanie for checking.
- Do not personalize your text, use passive language or 'the team or project'
- Calibri 11 with "no distance"
- Use Header 1 for a chapter and other headers for subjects.
- Clearly put in effort and time.
- Don't copy and paste from the internet: Reference about it!

3. What are agreements about checking the documents?

- Use comments to check the informational text. Language check you can adjust right away.
- Planning in Trello.
- References: Citethisforme.com use Harvard

4. How do we deal with language/style errors in the documents that are handed in? (How do we check this and what do we do when it is not good?)

- Do a language check by yourself before. After that you can also send it to Stephanie for checking.

5. What if:

- Leaving early
    - i. Tell before the meeting starts
- Not being there with reason
    - a. You have to let it know in advance preferably the day before.
    - b. Good reasons are:
        - i. Doctor, dentist
        - ii. Family or friend or personal problems
        - iii. Illness

- Not being there without reason
    - **a.** First warning, second time discuss with coaches
    - Examples of not a good reason: Party, hangover, without letting anything know.

- Bad communication
    - a. Talk directly to the person and try to solve the problem respectfully. When that doesn't work, go to the chairman to find a solution. When that doesn't work the chairman will talk with the coaches and the group.
- Don't follow up agreements
    - a. Below is the so called "responsibility table" shown:

Case:	**Are you aware of your responsibility?**	**Good reason for not finishing?**	**Was the reason known in advance?**	**What should be done the next time?:**
1	Yes	Yes	No	Not your fault
2	Yes	Yes	Yes	Communicate better!
3	Yes	No	No	Unacceptable
4	Yes	No	Yes	Unacceptable
5	No	Yes	No	Communicate better!
6	No	Yes	Yes	Communicate better!
7	No	No	No	Communicate better!
8	No	No	Yes	Communicate better!

In the table above is schematically shown which questions should be asked in what order when a task is not completed. The first question is if someone is aware of their responsibility, so if they know that they had a task to do. The second question should be if they have a good reason for not finishing the task. The last question which should be asked is if they knew the reason for not doing their responsibility. Each question has two answers, yes or no, so the total amount of solutions is: 2*2*2 = 8

- **b.** In case of point 2 up to and including point 8: first time, warning. Second time talk with coaches.

- Bad quality of documents handed in
  a. Check first if you can understand it yourself!
  b. The checker needs to put one comment and could also contact the person and talk about it and offer help.
  c. When a person keeps handing in documents with bad quality, discuss it with the group and if necessary with the coaches.

- Showing up too late
  a. When there is for example a meeting at 10.30 you have to be there ready to have the meeting. When you are too late you have to bring a treat with you at the next meeting.
  b. When you are more then 10 minutes too late you should give a reason in advance. If you cannot give a reason the rules for 'Don't follow up agreements' are working.
  c. Don't make a habit of being to late. If you do you will get a warning.

- Inappropriate work behaviour
  a. You can't use your phone during meetings unless it is necessary for the meeting.
  b. You can use your phone whenever you want unless it won't effect your work or the work of others. When it does, make agreements about it in the moment.
  c**.** When someone is presenting their work or presenting we should pay attention. No laptops, no phones, no whispers, no giggles, no laughing at each other.

6. **How much time do we expect to spend on the project?**
a. 37,5 hours per week per person (included subcourses like Swedish and project management etc.).

7. Meetings
We fix the next meeting time one week before