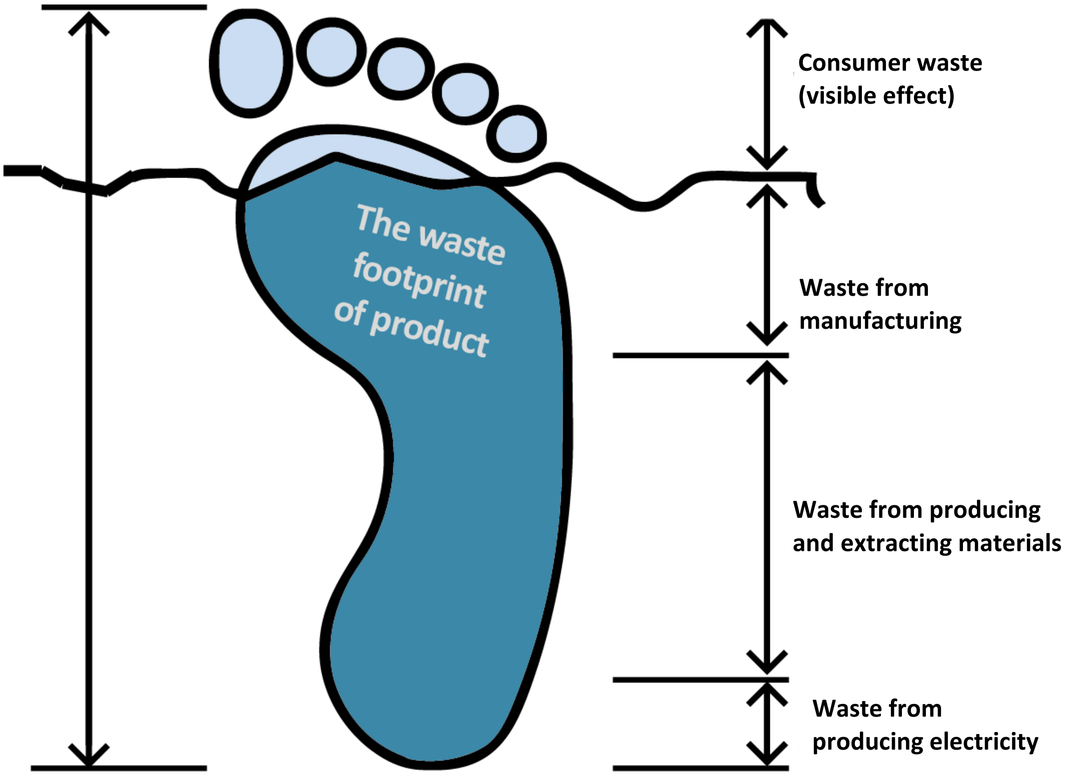
POPULAR SCIENCE REPORT



The total waste of products – a study on waste footprint and climate cost

Rafael Laurenti and Åsa Stenmarck
with contribution from Åsa Moberg, Jan-Olov Sundqvist, Haben Tekie, Lena Youhanan

Author: Rafael Laurenti and Åsa Stenmarck
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IVL Swedish Environmental Research Institute Ltd.
P.O. Box 210 60, S-100 31 Stockholm, Sweden
Tel: +46-10-7886500, Fax: +46-10-7886590
www.ivl.se

Executive summary

Except from the waste that results as a produced is used and discarded, waste is generated during production of the product itself. Consumers may have difficulties to in realizing the full extent of the impact that their consumption behaviors have on the environment as they only see the waste generated in the household. Without comprehensive information about the lifecycle impacts of goods, consumers cannot adopt consistent sustainable conducts. In this study we developed a waste footprint metric in order to improve understanding and awareness of consumers about the total waste generated in the course of producing the goods they consume.

We calculated the waste footprint of 11 products and estimated the climate cost due to the greenhouse gas emissions related to the production processes. The consumer goods assessed were chicken and beef, an electric drill, a laptop computer, a liter of milk, a pair of trousers, a pair of leather shoes, a smart phone, training clothes (a T-shirt and a pair of shorts in polyester), carton milk packaging and a newspaper.

Among the products analyzed, electro-electronic products have the highest waste footprint (kg/ product), a laptop computer 1200 kg, a smart phone 86 kg and an electric drill 52 kg. One kg of beef generates more waste (4 kg) than one kg of chicken meat (860 gram). One liter of milk has a relative low waste footprint (97 gram) but its waste footprint increases around 10 percent when the footprint of its packaging (9 gram) is added to it. The waste footprints of clothing (pair of trousers 25 kg, training t-shirt and shorts 17 kg) and footwear (pair of leather shoes 12 kg) also deserve the attention of consumers. A copy of a newspaper proved to have a small waste footprint (25 gram). The main sources and reasons of waste generation are described in this report.

The climate cost of a laptop computer (270 SEK) and mobile phone (140 SEK) was highest, in line with the waste footprint. One kg of beef (37 SEK) and a pair of leather shoes (14 SEK) appeared in the third and fourth position respectively; one kg of beef also has a much higher climate cost than one kg of chicken meat (5 SEK); the climate cost of a pair of trousers (8 SEK) and training clothes (7 SEK) are quite similar. The climate cost of 1 liter of conventional milk (1.4 SEK) is higher than that of its packaging (smaller than 1 SEK); the newspaper has a small climate cost (smaller than 1 SEK).

Calculating the waste footprint of consumer goods using a life cycle approach, where the waste generated during the production process is assessed, proved to have some methodological limitations – e.g. definition of waste, data availability and variability of cases. Yet, these limitations do not mean that the results are invalid. The results should be seen as an indication; and the limitations need further consideration in future studies. Calculations of climate costs are based on valuation as suggested in one specific model and are connected to uncertainties, as valuations always are.

The results demonstrate that there are great environmental benefits by producing less consumer goods and use the products more efficiently because only then it is possible to reduce the overall waste footprint from our consumption. We thus argue for the importance of changing consumption patterns, and advocate for novel business models based on a use-oriented consumption (sharing and reusing) that encourage different ways of consuming and more sustainable life styles.

1. Introduction

Today you may have had a glass of milk during your breakfast. You maybe took the last of the milk and then you hopefully sorted the milk packaging for recycling. Before leaving home for work, you may have packed clothes for training after work and put on a pair of leather shoes. You may have taken a free newspaper for and spent 20 minutes reading it on your way to work. Right now, you are sitting in front of your laptop computer wearing a pair of trousers with your mobile phone in your pocket; you are considering whether to eat meat balls or chicken curry for lunch. You buy new clothes and a new mobile regularly and you sort for recycling all your waste; you are comfortable about having some food waste since it is sorted for biological treatment. However, have you ever thought about the environmental impacts that your consumption choices cause in other parts of the world? Can you guess how much waste has been produced in order to provide the products you consume? Do you know their carbon footprint? And how much are you willing to pay to offset the environmental damage of your consumption?

While most people are aware of the amount of waste that they separate for recycling, relatively few are aware of the waste generated during the course of producing the goods that they consume, e.g. waste generated by extracting resources, transporting, producing fuels and electricity, manufacturing, etc. Except from the consumer waste generated when the user decides to discard a product, industrial wastes are created throughout the production chain when producing each product. Figure 1 illustrates the life cycle of products emphasizing the waste produced during raw materials extraction and production, manufacturing, electricity production, packaging and end of life. The waste generated upstream from the point of consumption is defined as the waste footprint.

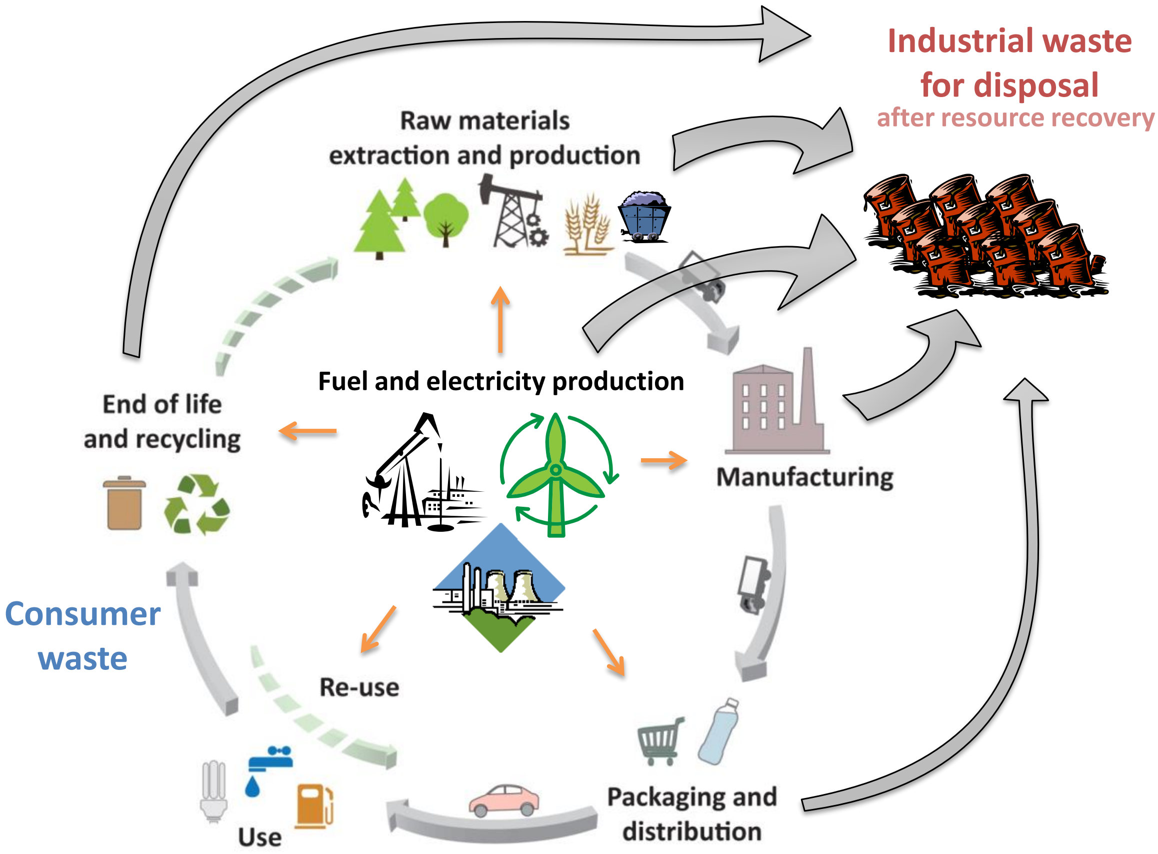

Figure 1 - Life cycle stages of a product and waste generated. Grey arrows represent flows of materials; orange arrows represent energy flows; flows recovered onsite are omitted

The aim of this study was to develop a method to assess the waste footprint of products and to estimate the waste footprint and climate cost of 11 selected consumer goods – chicken and beef, electric drill, laptop computer, milk, milk packaging, newspaper, pair of trousers, pair of leather shoes, smart phone and training clothes (T-shirt and shorts). To calculate the waste footprint we used methodology from the life cycle assessment (LCA) framework and life cycle inventories of materials, industrial processes, chemicals, components, etc. available in commercial databases, technical reports, theses and scientific articles. To calculate the climate cost we utilized a system called environmental priority strategies in product design (EPS)1. The climate cost calculated was only for greenhouse gas emissions (carbon footprint). The full environmental cost caused by all other resource use (e.g. water, metals, bio-mass, use of land, etc.) causing other discharges than greenhouse gas emissions as well as other environmental damage (e.g. loss of resources and biodiversity) during the life cycle of a product is not assessed here due to limited data availability and uncertainties in valuation. The LCA and EPS methods are further described in Appendix 1 and 2.

The study adopted the EU Waste Framework Directive to interpret and account what is 'waste'. The framework defines waste as an object the holder discards, intends to discard or is required to discard. The study used the system model "allocation, cut-off by classification" in the LCA-database ecoinvent 3 as a source of data. In this model flows from production processes that may be recycled for material or recovered for energy are not accounted for as waste. This means that some flows that would normally be considered waste are not included in the calculations, but also that some flows which would be considered for recycling or energy recovery in Sweden are considered waste as they are not recycled or recovered in general in Europe. No waste related to transportation of material or products are considered in the study, due to uncertainties in estimating transport distances.

More details about how the waste footprint and climate cost metrics were calculated and methodological limitations and assumptions are given in Appendix 1. A reference group with representatives from industry performed a reality check in the results of the footprint calculation.

Due to the impossibility of modelling exactly the reality, the results presented in this report are only indicative. The present study attempts to quantify orders of magnitude and define types of waste generated as well as reasons for the generated waste in connection with the production of consumer products.

2. Results

The results of the waste footprint analysis are presented in the Figures 2-12 below.

To illustrate more clearly how much different processes of the overall production chains contribute to the respective waste footprint a presentation of most important processes are given (blue boxes in Figures below). In these blue boxes the quantity (weight) of waste generated is highlighted; a brief explanation about the reasons, sources, and representative examples of waste generated is also given. The waste from the sub-processes is aggregated into the total waste footprint (red box), for the carbon footprint and its climate cost is also presented. Details about the composition of the products, system boundaries and percentage of contribution of waste sources to the waste footprint can be found in Appendix 2, 3 and 4 respectively.

[1] For further information on the EPS see appendix 1

2.1 Food

Chicken meat

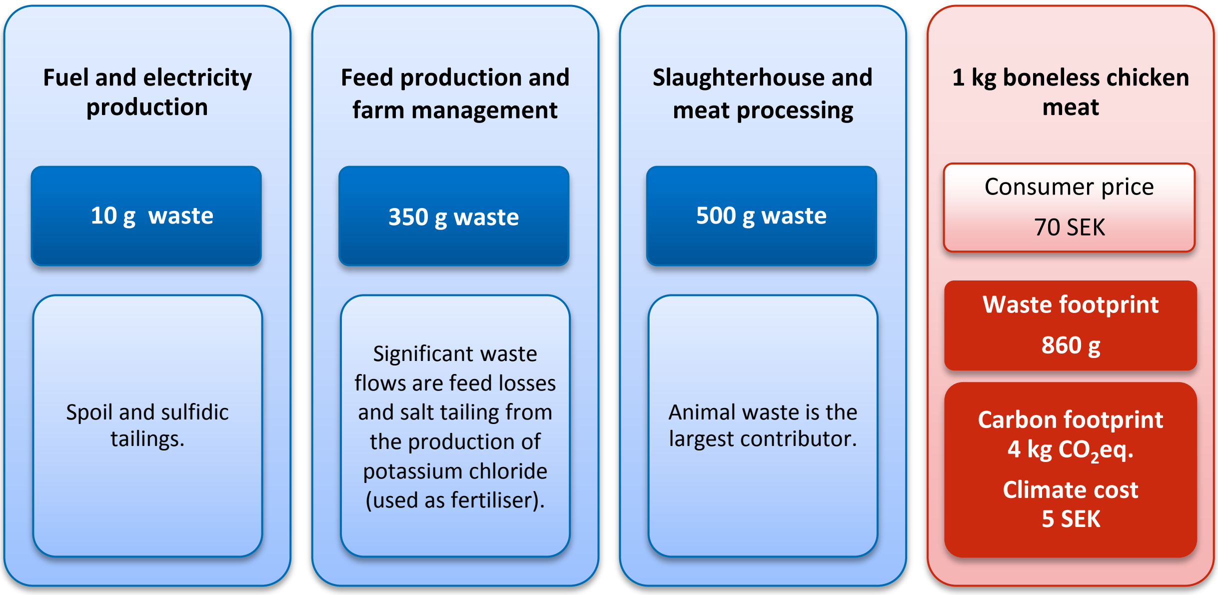

Figure 2 – Quantities of waste generated in chicken meat production; these quantities are expressed for 1 kg of boneless chicken meat. Consumer price is an estimate of the price at the supermarket. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

Beef

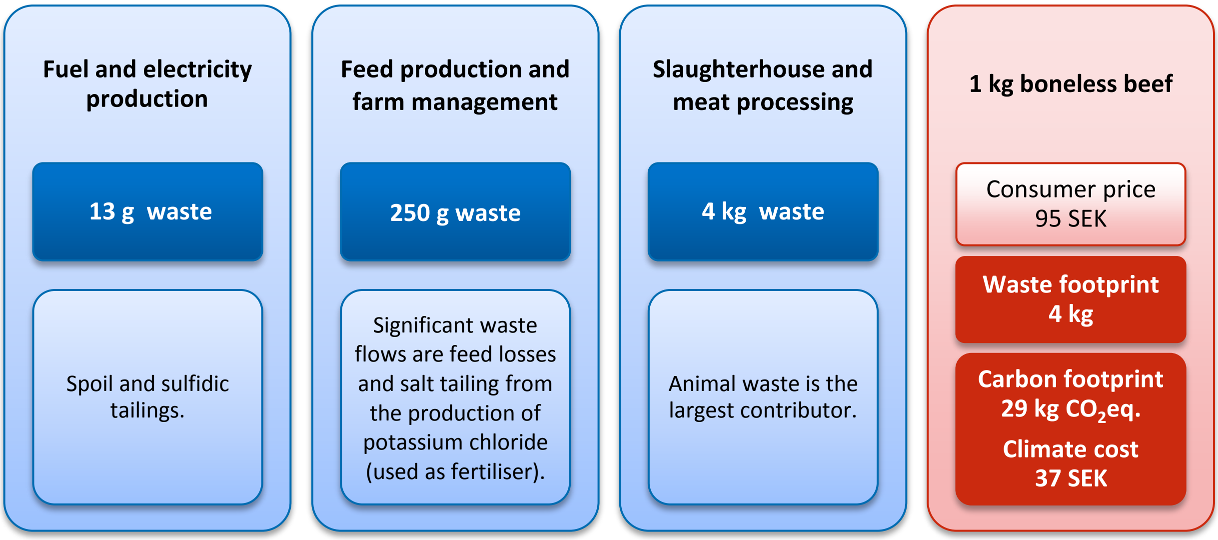

Figure 3 – Quantities of waste generated in production of 1 kg beef. Consumer price is an estimate of the price at the supermarket. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

Milk

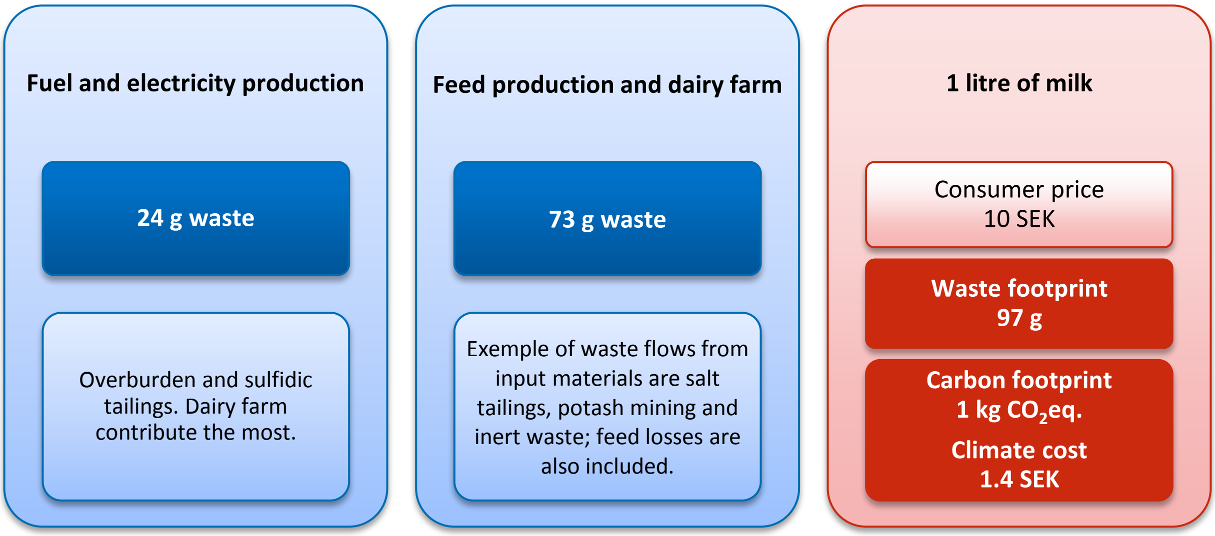

Figure 4 – Quantities of waste generated in 1 liter cow milk production. Consumer price is an estimate of the price at the supermarket. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

2.2 Electro-electronics

Electric drill

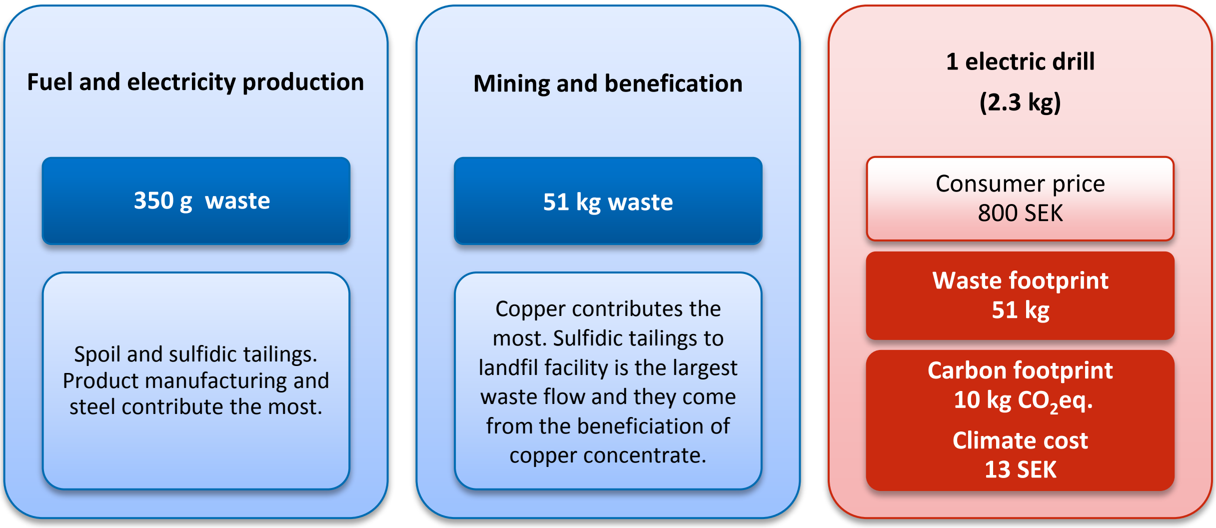

Figure 5 – Quantities of waste generated in production of a 2.3 kg electric drill. Consumer price is an estimate. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

Laptop computer

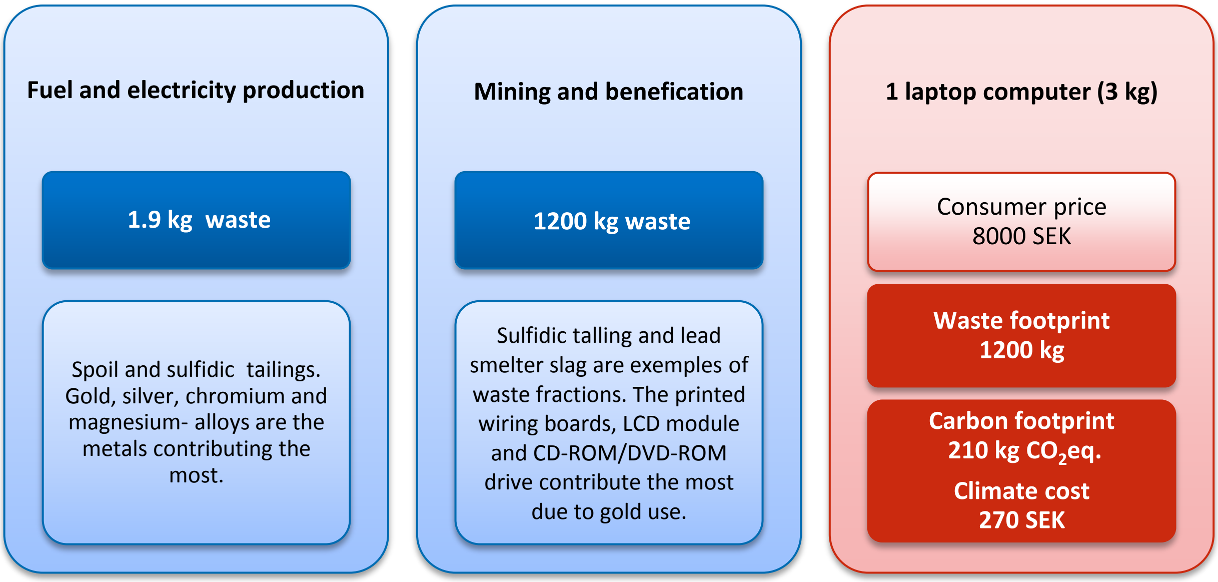

Figure 6 – Quantities of waste generated in production of a 3 kg laptop computer. The consumer price is an estimate. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

Smart phone

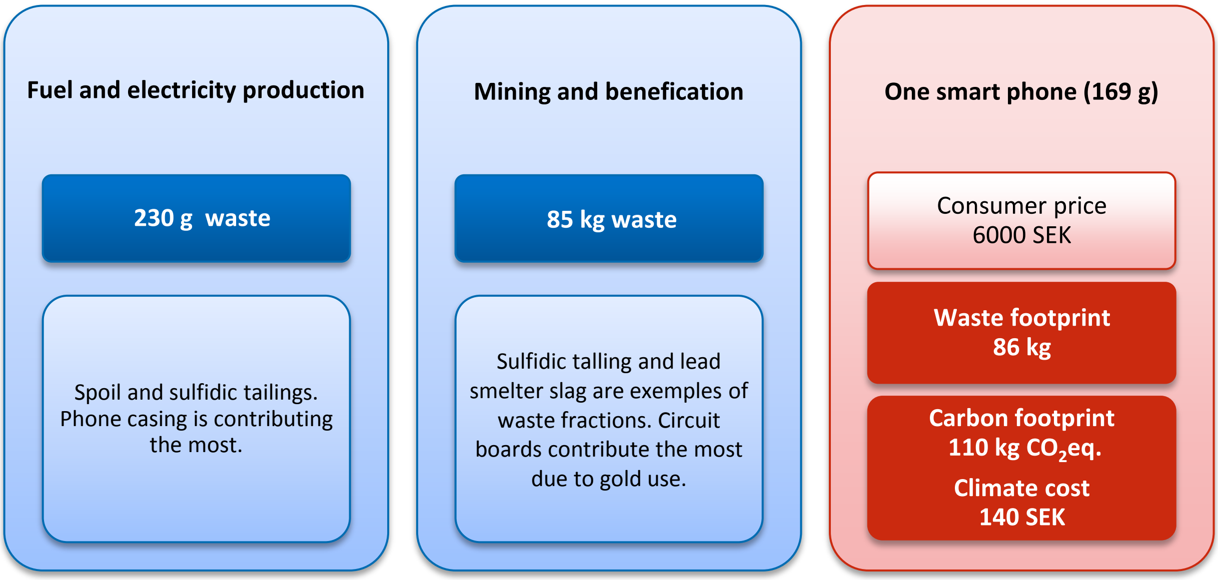

Figure 7 – Quantities of waste generated in the production of a 169 g smart phone. The consumer price is an estimate. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

2.3 Clothes and footwear

Pair of trousers

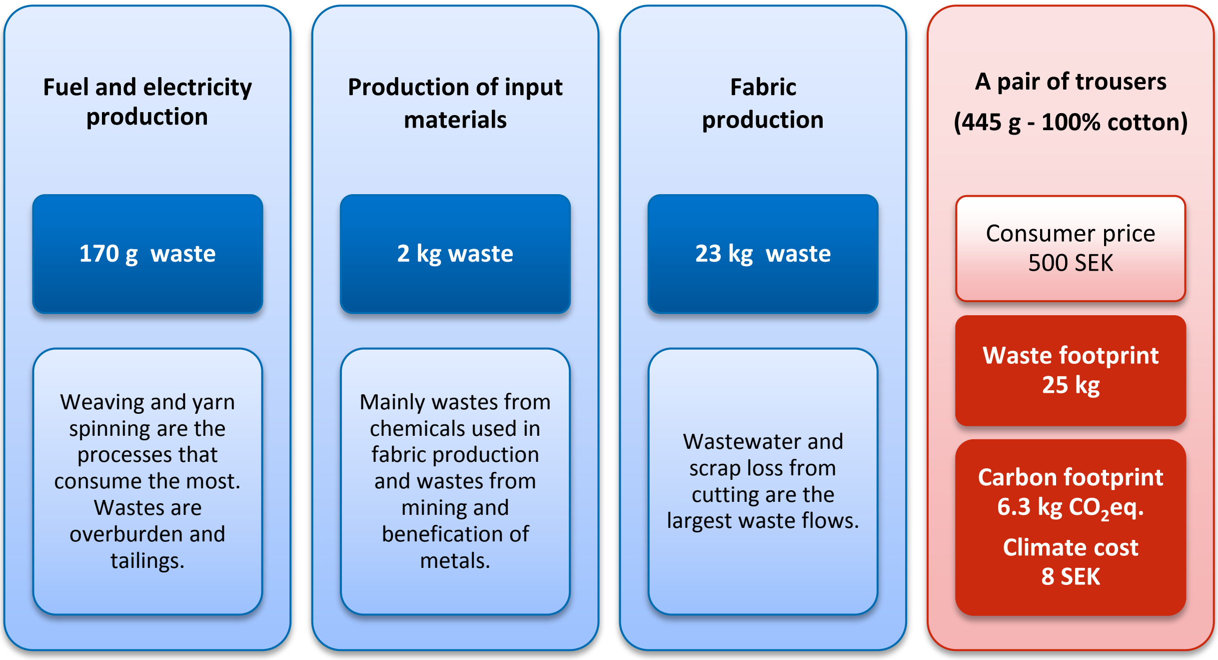

Figure 8 – Quantities of waste generated in the production of a pair of 445 g trousers. The consumer price is an estimate. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

Training clothes

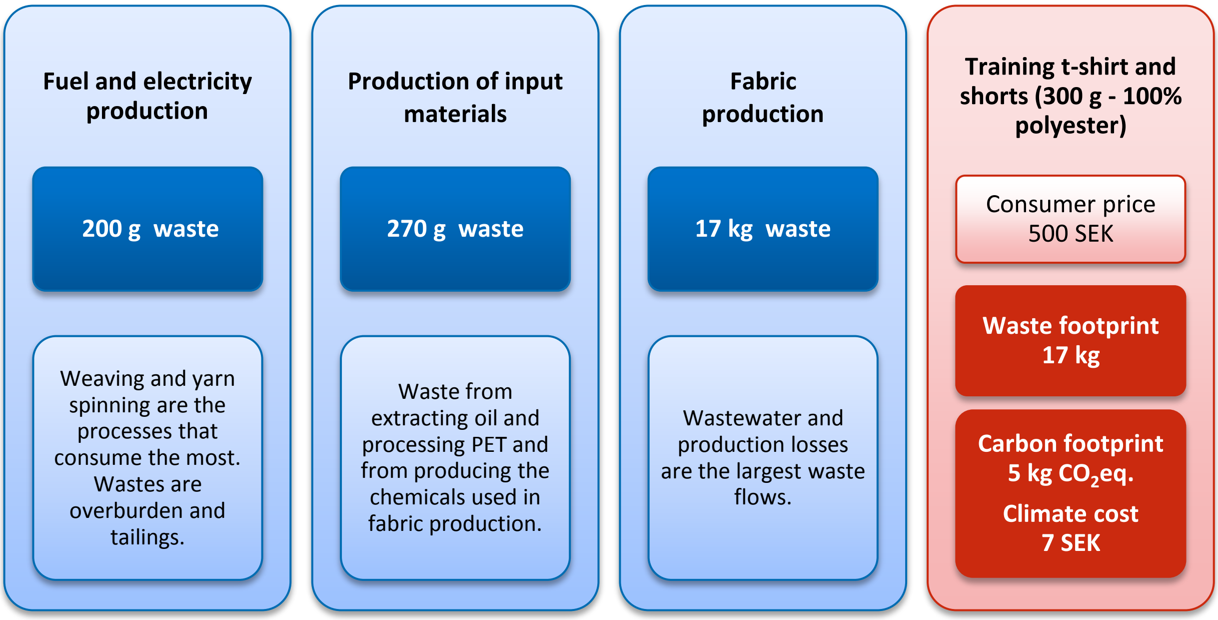

Figure 9 – Quantities of waste generated in the production of 300 g training clothes. The consumer price is an estimate. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

Pair of leather shoes

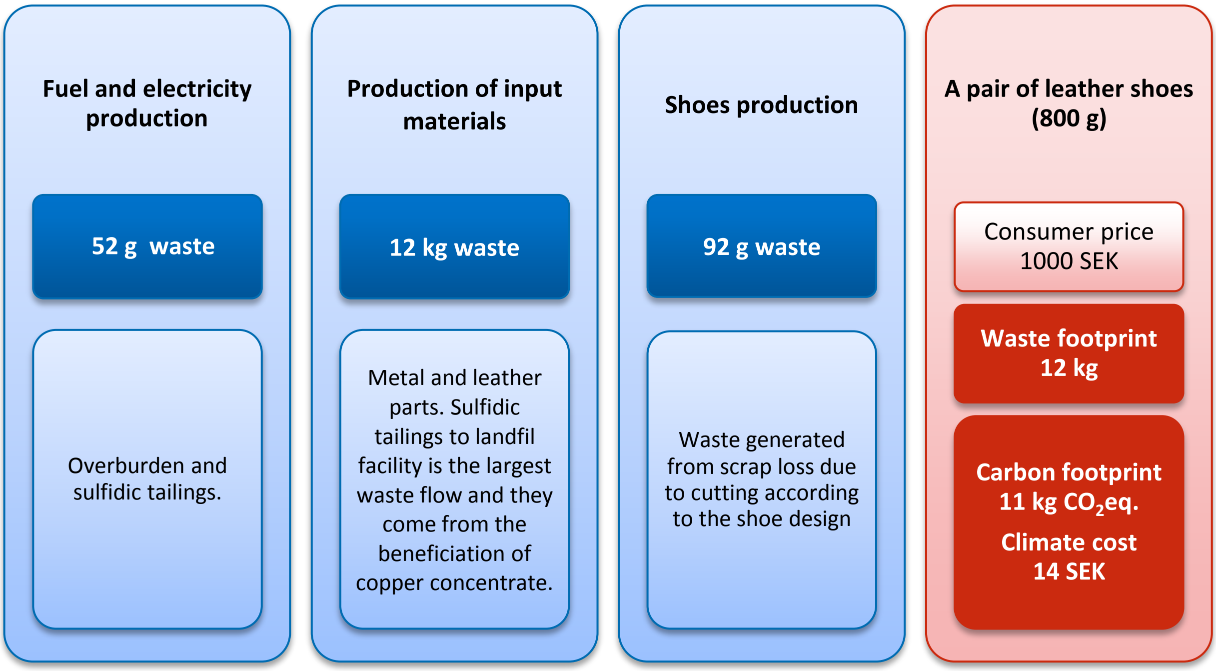

Figure 10 – Quantities of waste generated in the production of a pair of leather shoes. The consumer price is an estimate. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

2.4 Milk packaging and newspaper

Milk carton packaging

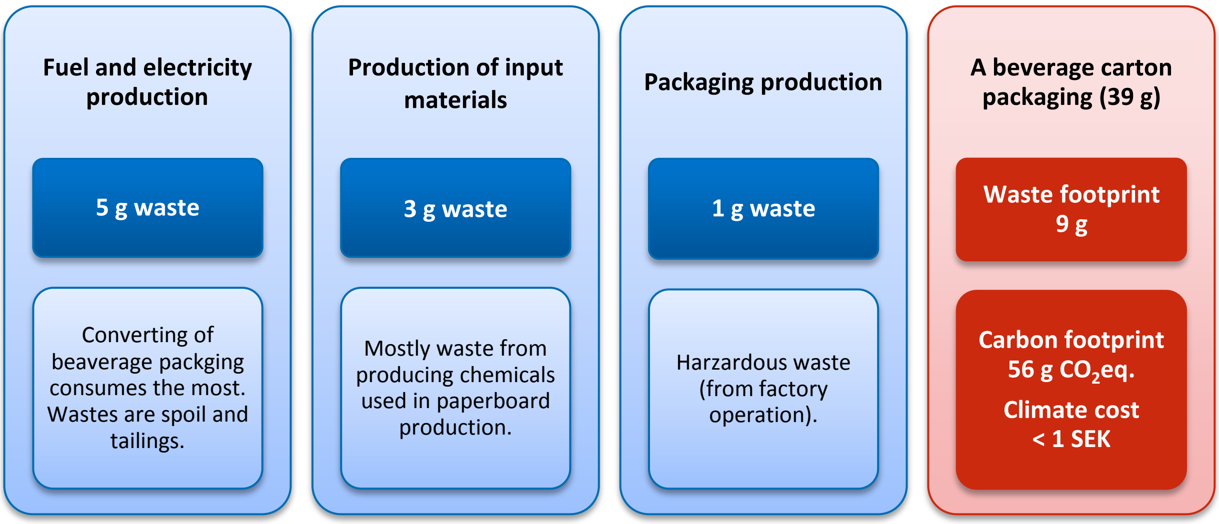

Figure 11 – Quantities of waste generated in the lifecycle stages of a beverage packaging. The consumer price is an estimate. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

Newspaper

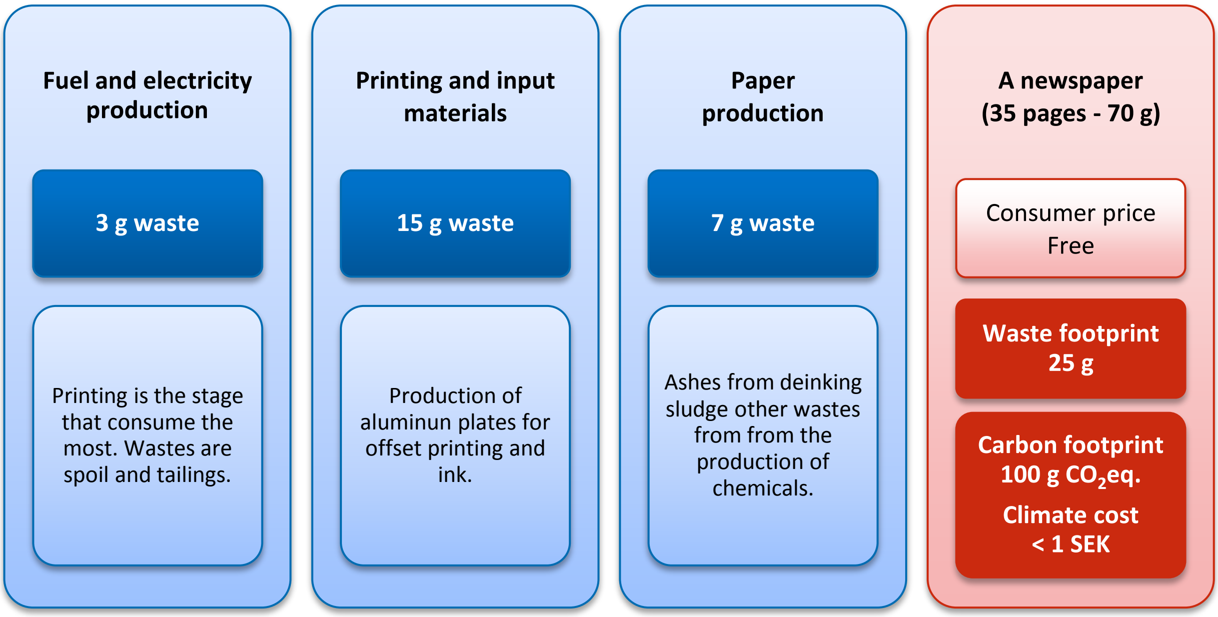

Figure 12 – Quantities of waste generated in the production of a 35 pages newspaper. The climate cost was calculated for the greenhouse gas emissions (carbon footprint) for the total waste generated throughout the production chain.

3 Discussion

3.1 Waste footprint

Figure 13 summarizes the results. Among the products analyzed, electro-electronic products have the largest waste footprints; beef scores higher than chicken meat; milk has a relatively small waste footprint and its waste footprint increases approximately 10% when the footprint of its packaging is added to it; the waste footprints of clothing are also relatively large. The different waste footprints are not directly comparable, as the function provided by the products are not the same.

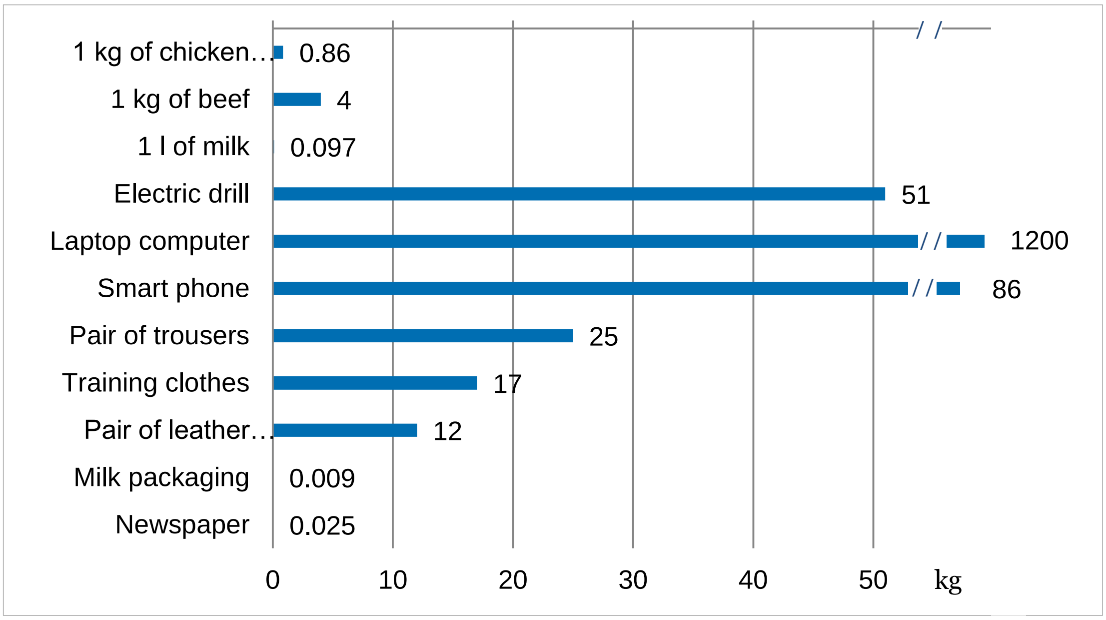

Figure 13 – The waste footprint of the studied consumer goods. The bar of laptop computer and smart phone are not on scale.

Expectedly, the waste footprint analysis indicated that the waste that consumers dispose is only a small fraction of the total waste generated in our economy due to consumption. Most of the total waste occurs upstream from the point of consumption during the production of fuels, electricity and materials necessary to produce consumer goods.

Quantities and points of waste generation can differ quite radically. This is evident in Figure 14 which shows the percentage of contribution of production stages to the waste footprints. For electro-electronic products, for example, mining and beneficiation are the main source of large quantities of waste; the waste from final production is the greater contributor to the waste footprint of clothes (wastewater in fabric production) and chicken and beef (slaughter waste); the production of input materials, specially leather and metal parts, are the largest sources of waste for leather shoes; wastes from fuel and electricity production are more evident for, milk packaging and milk.

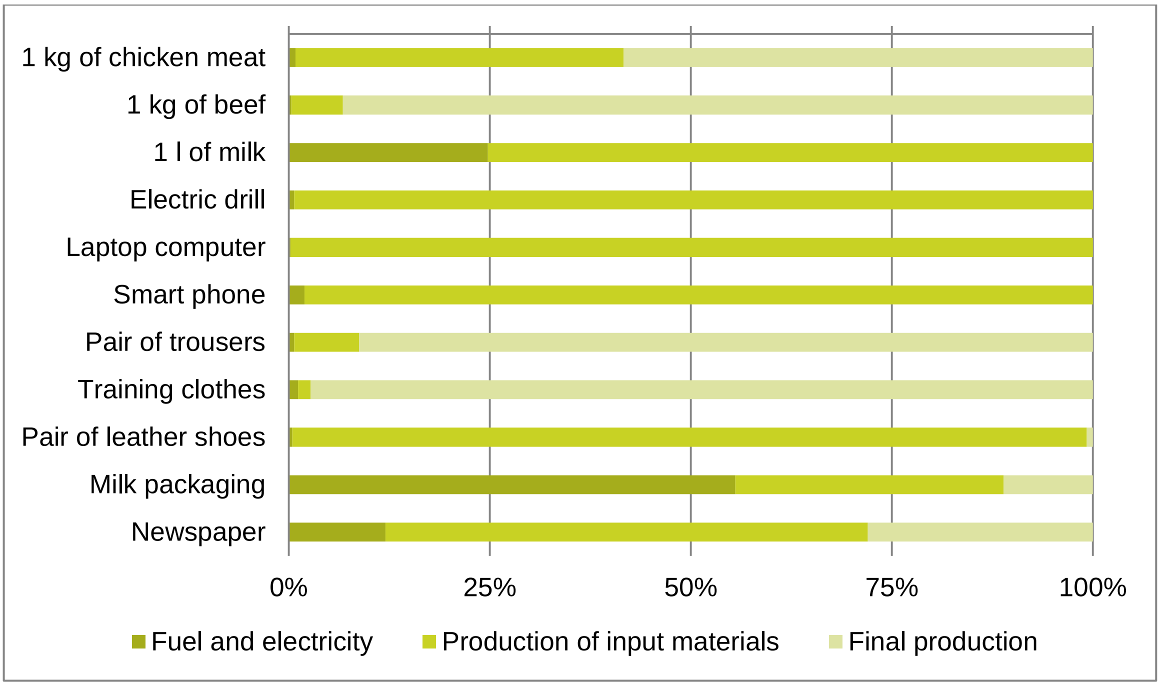

Figure 14 – Percentage of contribution of production stages to the waste footprints of the analyzed consumer goods

It should be noted that waste that can be recycled for material or recovered for energy, according to the data source, is not included in the waste footprints above. Would they have been included the footprints would have been considerably larger.

3.2 Climate costs

Figure 15 summarizes the climate cost of greenhouse gas emissions related to the waste generated due to the production of the analyzed goods. This indicator gives a different picture than the waste footprint did. Laptop computer and smart phone still resulted in the highest results; but beef and leather shoes appeared in the 3rd and 4th position respectively; the production related waste of beef also has a much higher climate cost than that of chicken meat. The climate cost of production related waste for trousers and training clothes are quite similar; differently with the waste footprint, the climate cost of production related waste for 1 liter of milk is much higher than the one of its packaging.

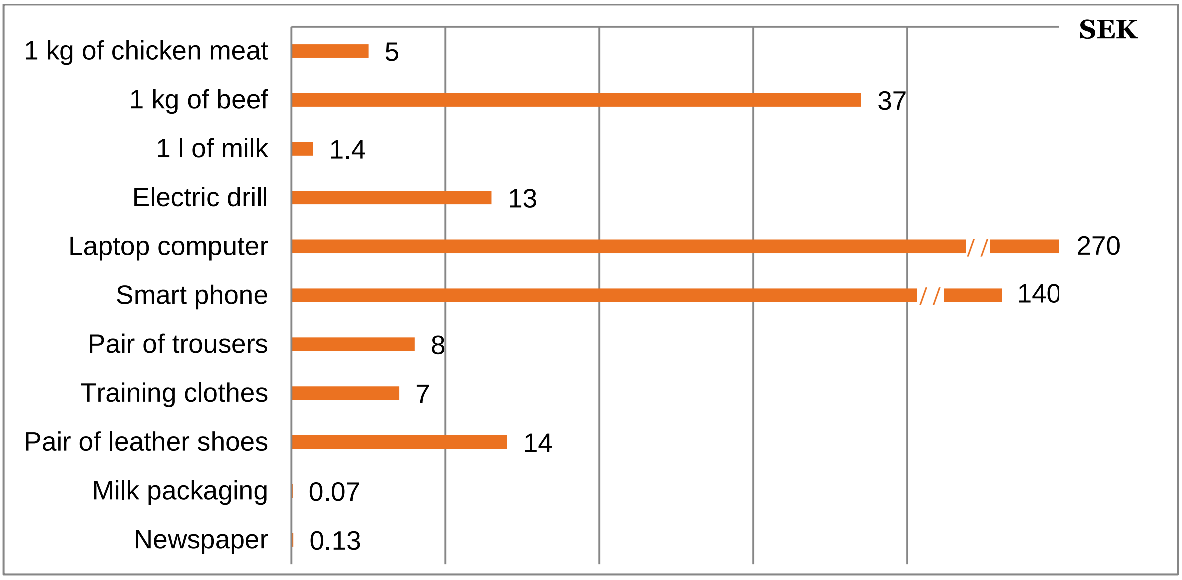

Figure 15 – The climate cost of greenhouse gas emissions connected to the products' production related waste. Values are expressed in SEK. The bars of laptop computer and smart phone are not on scale.

3.3 Opportunities for future studies

Specifying the types of waste and decrease data gaps
A waste footprint study would provide more detailed results if more information about the waste composition (type of waste such as hazardous, inert, organic, etc.) was available. A categorization in different levels of hazardousness should for example illustrate the difference between 1 kg of gravel from 1 kg of chemical waste. The present study faced many difficulties to undertake such task due to the way data is presented and aggregated in the commercial datasets and disclosed in LCA publications. In some cases all waste generated in the production chain is aggregated and it is not possible to tell where it was generated and what type of waste it is, In other cases it is possible, but time demanding, to manually collect and complement the waste data. LCA software providers (such as GaBi and SimaPro) could develop detailed data sets. More case studies focusing waste would increase the robustness in results and decrease the data gaps.

The waste footprints calculated within this study do not include waste that can be recycled or recovered for energy, according to the data source. To get more informative footprints it would be useful to include also these flows, and perhaps use different characterizations for them as well.

Giving information about the product parts
For certain types of products such as computers and mobile phones, the waste footprint could be communicated for the parts that can be replaced or reused (e.g. hard drive, screen, battery, etc.). This could encourage both producers and consumers to reuse as much as possible.

Moreover, it would be interesting to highlight how much of the accessories cables, chargers, etc) that are discarded immediately after opening the box and how large the related waste footprint is. This would illustrate the potential for saving resources by designing products with standardized accessories that can be reused, and thus do not have to be included in every new product set.

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Appendix 1 – How was this calculated

Life cycle assessment

The 'material' lifecycle of products starts[2] with the extraction and production of the raw materials necessary to produce the products. The material inputs are then manufactured into products. The products are packaged and distributed to consumers. Some products can be re-used by other consumers or purposes. When the products reach their end of life[3], they are sent to recycling or other treatment (e.g. incineration and landfilling). In addition, most of these lifecycle stages require electricity and transports; electricity is produced differently in different countries, e.g. from hydro power, wind power, coal power and nuclear power; transports demand fuel that needs to be produced and transported.

Following the life cycle assessment framework, it is possible to compile inputs (materials, water and energy) and outputs (emissions[4], waste, co-products and product) for each of the relevant processes/activities occurring in the lifecycle stages of a product. This compilation is called life cycle inventory and it is carried out based on a functional unit[5] and system boundaries[6] set according to the goal and scope of the investigation. The inputs and outputs of the life cycle inventory are then assigned to potential environmental impacts[7] using predefined characterization factors[8]. Conclusions and recommendations for improvement actions are finally made based on the findings. The results of LCA can assist decision-makers at several levels (e.g. managers, product designers) in strategic planning, material selection, and marketing purposes (e.g. informing consumers about the environmental performance of products) (ISO, 2006).

The present footprint investigation uses life cycle inventories of materials, industrial processes, chemicals, components, etc. to account for waste generated in the course of producing products, and the greenhouse gas emissions that is related to the waste generated. Commercial databases, technical reports, theses and scientific articles were the sources data.

[2] In a broader perspective, the lifecycle of a product actually begins at the product design stage (thus prior to raw material extraction) when materials and manufacturing processes are specified. Therefore the term 'material' is used to make this subtle distinction.
[3] Products can reach their end of life for many reasons such as because they are worn out, broken or technically or perceivably obsolete. It can also be products that are well functioning, but are discarded since they are not considered fancy enough or do not fit for other reasons.
[4] Solid, liquid and gaseous emissions to the air, water and soil.
[5] Functional unit is defined as "*quantified performance of a product system for use as a reference unit*" (ISO, 2006, p.4).
[6] The system boundaries is generally symbolised in graphical representation showing which lifecycle stages/processes are part of the LCA analysis being carried out.
[7] Examples of potential environmental impacts are global warming, acidification, eutrophication, cumulative energy demand, toxicity and resource depletion.
[8] This is done in order to be able to summarize different inputs' and outputs' contribution to an impact into one number. For example, for global warming carbon dioxide equivalents are used as the common unit. For all greenhouse gases there is a characterisation factor describing how many carbon dioxide equivalents that the emission of the gas equals. In this way the overall potential environmental impact of global warming can be assessed.

Climate cost

In terms of environmental economics, a so called negative environmental externality occurs when an activity by some party causes an unintended loss in welfare to another party, and no compensation for the change in welfare occurs. For example, when you drive your car you get the benefit of private transportation but the air pollution cause a cost for the rest of the society.
A system called environmental priority strategies in product design (EPS) was initiated in 1989 to calculate the environmental cost of products. The EPS was developed on demand from Volvo Automotive Company and as a co-operation between Volvo, IVL Swedish Environmental Research Institute and the Swedish Federation of Industries (Tekie and Lindblad, 2013). The purpose was to use EPS within the product development process as a tool to help assess the environmental performance of products (Steen, 2000).

EPS uses inventory data, characterization factors and weighting factors to monetarize the environmental impact (Westerdahl et al., 2011). The environmental impact on five different safeguard subjects is evaluated: human health, abiotic stock resources, ecosystem production capacity, biodiversity and cultural and recreational values. Monetarization of environmental impacts means that our values of the environment are described as the cost of different types of environmental damage. The EPS system offers a monetary value for individuals' willingness to pay (WTP[9]) to restore the damage in the safe guard subjects caused by the production of a product (Steen, 2000).

We used the EPS method to calculate the climate cost caused by the greenhouse gas emissions (carbon footprint) related to the waste generated in the production chain of the 11 selected consumer goods. The climate cost adopted for 1 kg of greenhouse gas emissions was 0.135 EUR[10] according to the EPS-method, in the study this was transferred into SEK (1.30 SEK/kg CO_2-eqvivalents).

Methodological limitations and assumptions

The term waste is frequently subjective because what is waste to one person may be raw material to another. However, governmental organizations and regulators provide clear definitions and guidance for classifying waste. For example, the Statistics Division of United Nations define waste as (United Nations, 2000, p.227): "[…] *materials that are not prime products (that is, products produced for the market) for which the generator has no further use in terms of his/her own purposes of production, transformation or consumption, and of which he/she wants to dispose* […]". The EU Waste Framework Directive stablishes waste as an object the holder discards, intends to discard or is required to discard (The European Parliament and the Council of the European Union, 2008).

[9] The concept of WTP was extended from the economic theory of value to natural resources like water and trees in environmental economics. Economic methods are used to attach estimates of willingness to pay to changes in the level of environmental quality and natural resource use.
[10] EPS version 2015d: Monetarised impact values at endpoint level. Supplementary material.

In the present footprint study 'waste' was interpreted at a simple level as "*substances or objects which the holder intends or is required to dispose of*". Figure 16 illustrates which waste flows were accounted. Thus:

- Material flows specified in the data sources as 'waste' or 'sent to disposal' were accounted (even though some material flows are recycled in some cases). In the database used, waste does not cover flows that can be recycled or recovered for energy.
- Liquid or gaseous wastes were not included (excepting wastewater in clothes production and leather tanning).
- Output material flows, from material transformation processes, that are recovered onsite were not accounted.
- Solid waste generated due to electricity and fuel (coal, diesel, natural gas used in in thermal industrial processes) production was included in scope of the waste footprint.
- Fuels needed for the transportation of materials and products were not included because of great uncertainties on actual distances.

This implies that some parts of materials that on other occasions would be classified as waste is not accounted for.

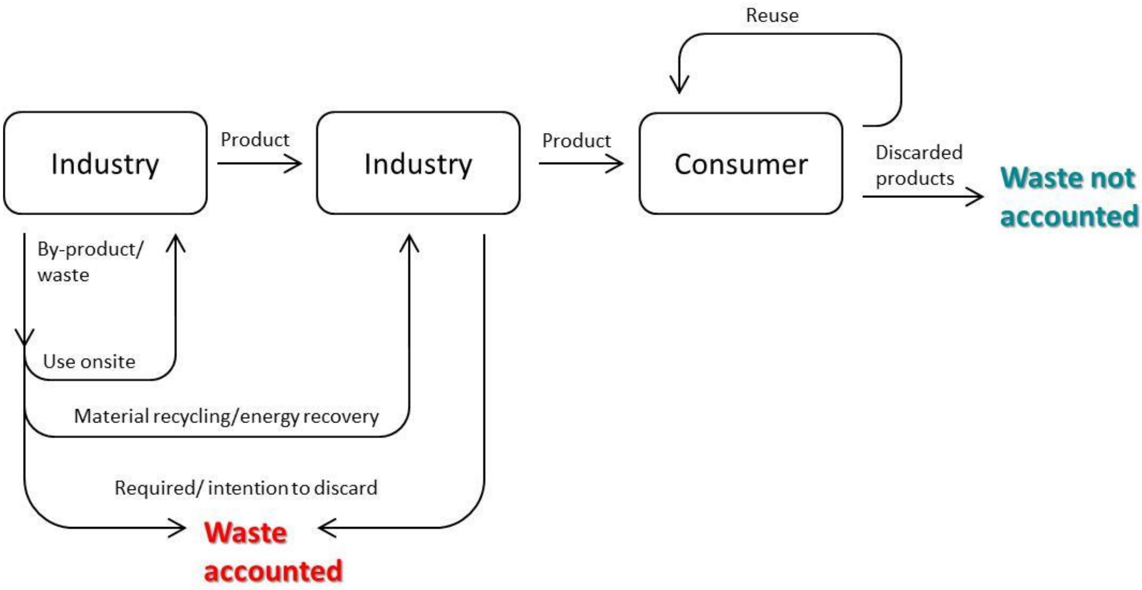

Figure 16 – Illustration of the waste accounted in the footprint study. Based on European Commission Directorate-General Environment (2012)

Evidently, there are several methodological limitations that concern the data such as availability, reliability, aggregation level and how representative the data are for a Swedish context and the products studied

- Data used represent European averages; thus it does not reflect any specific case. The electricity grid mix used was the EU-27.
- A large part of the waste footprint of many consumer goods are generated in producing countries such as China and India; hence the figures for waste from electricity production and other production processes are expected to be higher than those presented here.
- The amounts of waste accounted are based on secondary sources of data; thus, the quality and completeness of the results are limited to what was declared/ accounted in those sources. Wide variations can exist between different data sources and also between real processes.
- Flows that can be recycled for material or recovered for energy, according to the data source used, are not defined as waste in the data source and are not part of the waste footprints.
- The percentage of virgin and recycled materials sources in metals was considered (using recycled materials avoid waste related to the virgin materials).
- Some materials that were accounted as waste in the database can be sent to recycling; thus they could have been classified differently from the perspective of industrial actors.

Considering the uncertainties and limitations, the waste footprint values presented in this report should be seen as only as an indicative rather than a definite picture of reality. This study is a first attempt (screening) to quantify orders of magnitude, define types of and sources and reasons for waste generated in the course of producing consumer goods.

Appendix 2 – Composition of products

Food

Chicken meat
One kg of broiler chicken meat, boneless, produced in Europe.

Beef
One kg of boneless meat produced in Europe.

Milk
One liter of conventional milk produced in Europe.

Electro-electronic

Electric drill
A generic electric drill, weight 2.3 kg, for household purposes.

Table 1 - Product composition of the electric drill

Specification	**Weight (kg)**
Aluminum	0.053
Steel	1.3
Iron	0.14
Chromium steel	0.43
Copper	0.22
Plastic parts (nylon, polycarbonate, polyethylene, polyurethane, polyvinylchloride, silicone)	0.19
Total weight	**2.3**

Laptop computer

A typical laptop computer of a leading producer (12.1 inches screen, total weight 3 kg including with charger and cables). Material content of laptop parts like hard disk drive, CD- DVD-Rom drive, printed wiring boards (e.g. motherboard) and batteries were individually inventoried.

Table 2 - Product composition of a generic laptop computer

Component	**Unit**	**Quantity**
Lithium-ion battery	kg	0.27
Network cable	meter	0.16
CD-ROM/DVD-ROM drive	number of pieces	1
Hard disk drive	number of pieces	1
LCD module	kg	0.33
Inlet and outlet plugs	number of pieces	1
Power adapter	number of pieces	1
Printed wiring boards	kg	0.40
Metal parts (aluminum, chromium steel, copper and magnesium-alloys)	kg	1.3
Total weight	**kg**	**3**

Smart phone

A typical smart phone of a leading producer (5.5 inches screen, total weight 0.169 grams); charger, cables earphones and box are not included. Parts included are battery unit, aluminum and stainless steel casing, glass, display, circuit boards and plastic parts.

Table 3 - Product composition of a smart phone

Specification	Weight (g)
Battery unit	43
Phone casing (aluminum and stainless steel)	61
Glass	22
Display	19
Circuit boards	16
Plastic	8
Total weight	**169**

Clothes and footwear

Pair of trousers

A pair of trousers (100 percent cotton), 445 grams.

Table 4 – Composition of and main processes to produce a pair of trousers

Composition	Process	Quantity (g)
Fabric	Trimming and sewing Fabric finishing Fabric dyeing Fabric pre-treatment Weaving Cotton yarn spinning	430
Cotton bales*		550
Metal parts – brass (button, rivets and zipper)		10
Belt label (polyurethane)		10
Total weight		**445**

* The difference between the weight between the cotton bales and the fabric is due to material loss along the fabric production processes.

Training clothes

A t-shirt and a shorts for training (100% polyester), 300 grams.

Table 5 – Composition of and main processes to produce a training t-shirt and shorts

Composition	Process	Quantity (g)
Fabric	Trimming and sewing Fabric finishing Fabric dyeing Fabric pre-treatment Weaving PET yarn spinning	300
PET fibres*		380
Total weight		**300**

* The difference between the weight between the PET fibres and the fabric is due to material loss along the fabric production processes.

Pair of leather shoes

A pair of leather shoes size 40 (800 g).

Table 6 - Product composition of a pair of leather shoes

Components	Material	Weight (g)
Adhesive and solvents		15
Insole	Ethylene vinyl acetate (EVA)	30
Lining	Cotton	42
Laces	Polyester	16
Sole	Thermoplastic rubber (TR)	370
Upper and lining	Cow leather	307
Metal parts	Brass	20
Total weight		**800**

Milk packaging and newspaper

Milk carton packaging

A milk packaging with weight 39 grams, capable of storing 1 liter of beverage. The package is made from layers of paperboard and plastic film and has a plastic opening.

Table 7 - Product composition of and main processes to produce a beverage packaging

Processes and composition	Quantity (g)
Converting (energy for offices and workshops; extrusion and lamination; printing; cutting and packing)	-
Packaging production	-
Paperboard	27
Printing ink	3.6
Plastic film (LDPE)	7.6
Opening (HDPE)	3
Total weight	**39**

Newspaper

Newspaper made of recycle paper (deinked pulp – DIP), 35 pages, 70 grams.

Table 8 - Composition of and main inputs to produce a newspaper

Process	Composition	Quantity	Unit
Paper production	Newsprint	68	g
Printing	Ink	1.9	g
	Fuel	2.6	g
	Electricity	0.2	MJ
Packaging	Polyethylene	0.5	g
Total weight		**70**	**g**

Appendix 3 – System boundaries of the waste footprint analyses

Food

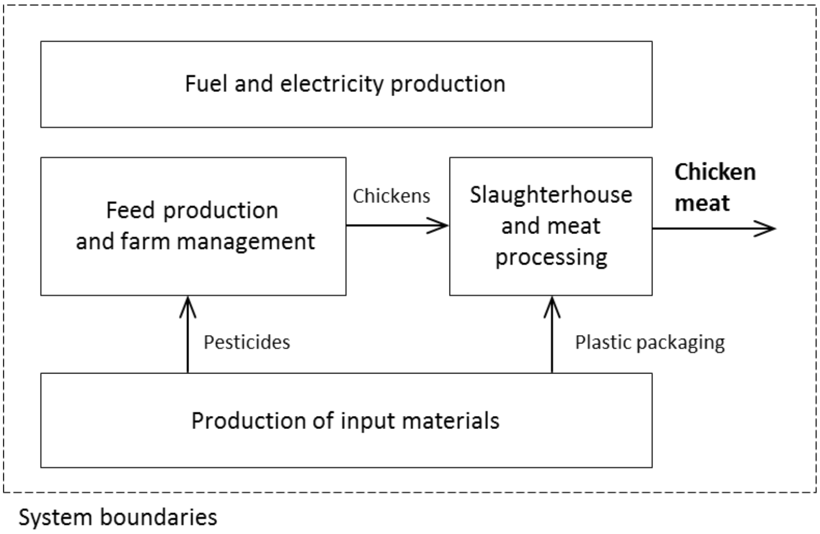

Figure 17 – System boundaries of the waste footprint analysis of chicken meat

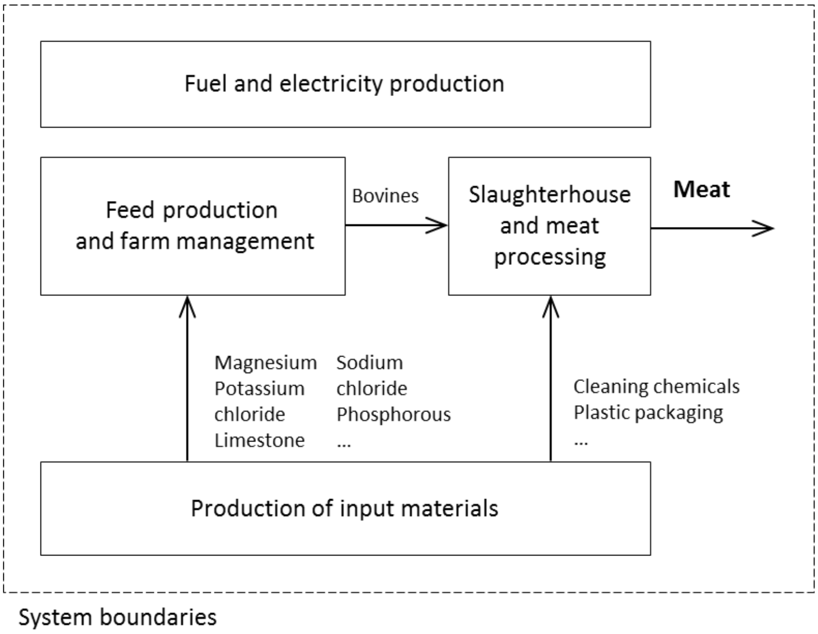

Figure 18 – System boundaries of the waste footprint analysis of beef

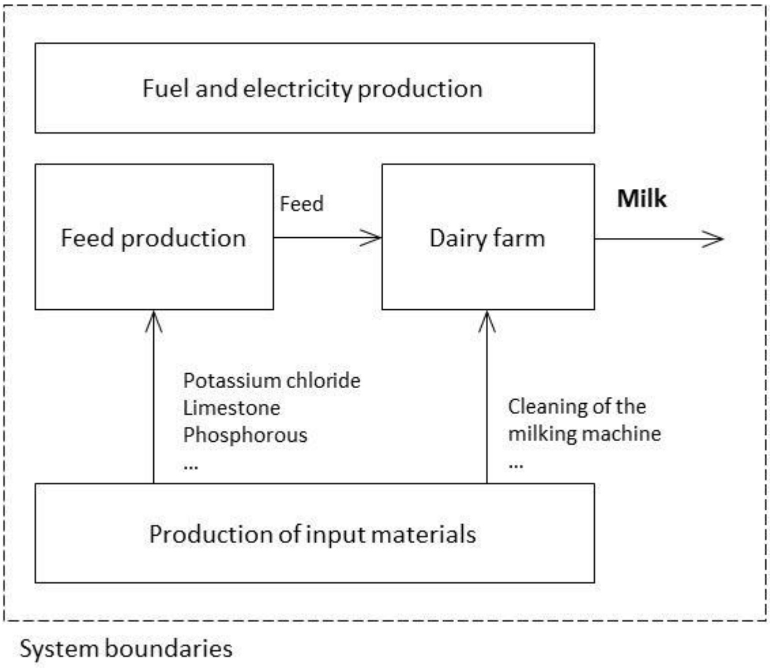

Figure 19 – System boundaries of waste footprint analysis of milk

Electro-electronic

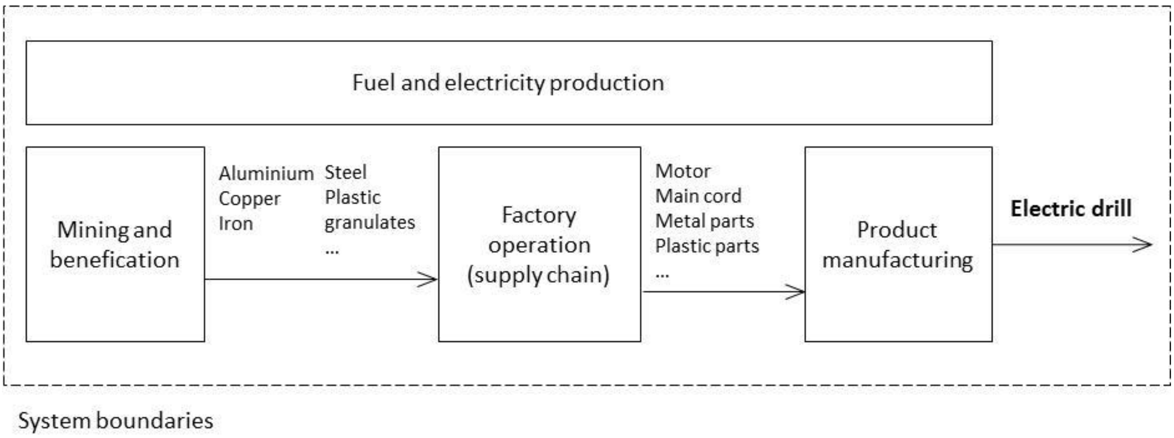

Figure 20 – System boundaries of the waste footprint analysis of an electric drill

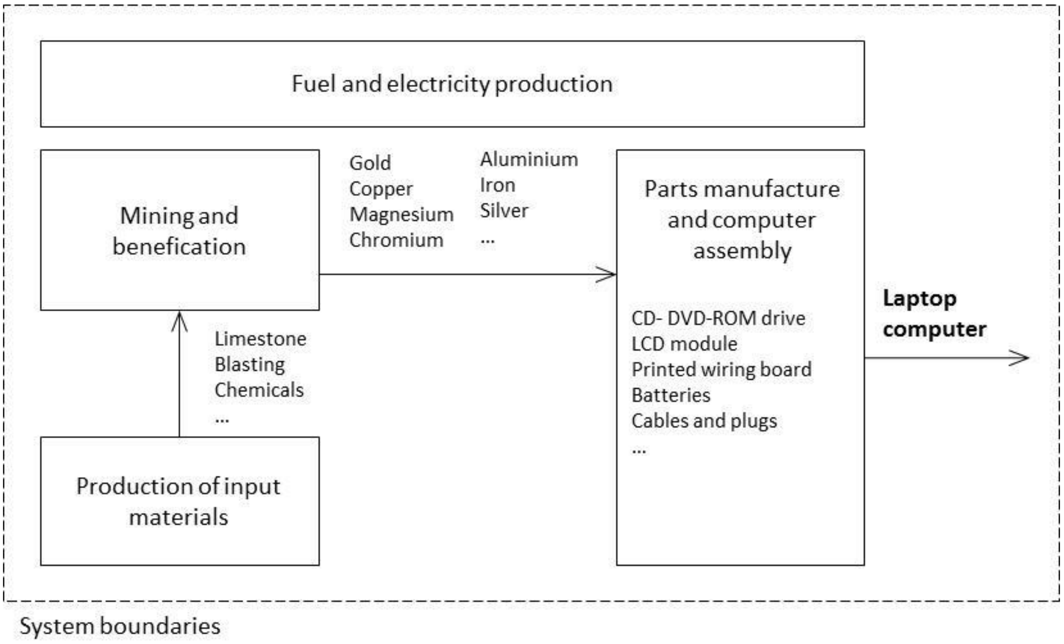

Figure 21 – System boundaries of the waste footprint analysis of a laptop computer

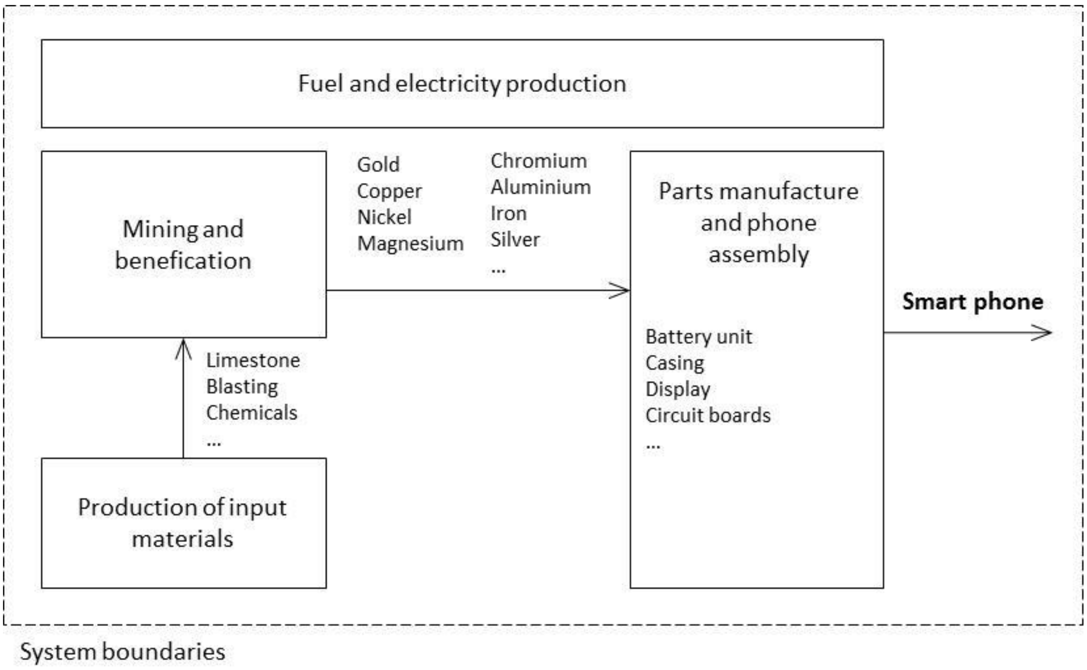

Figure 22 – System boundaries of the waste footprint analysis of a smart phone

Clothes and footwear

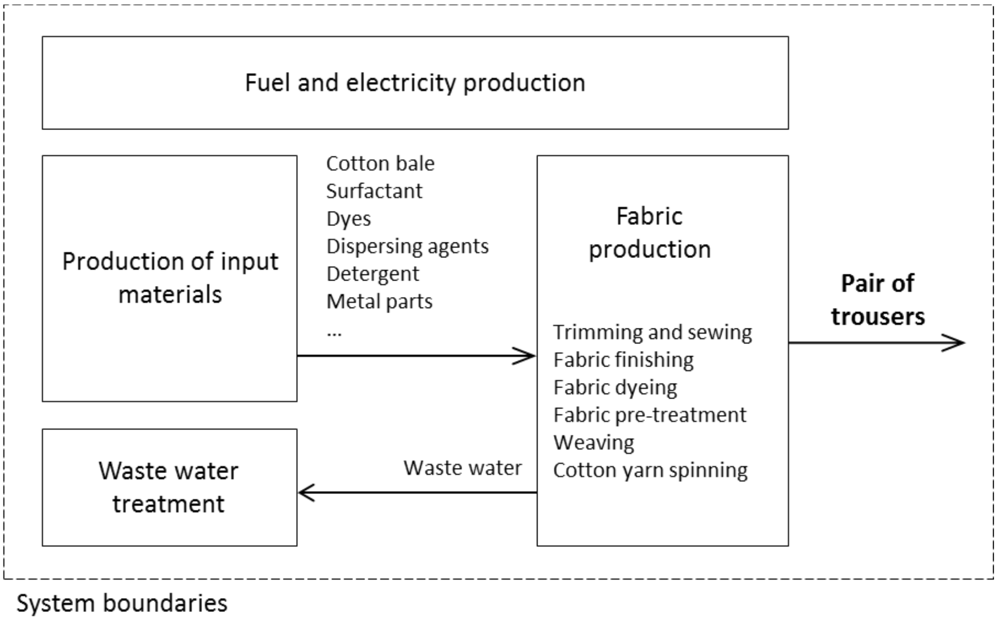

Figure 23 – System boundaries of the waste footprint analysis of a pair of trousers

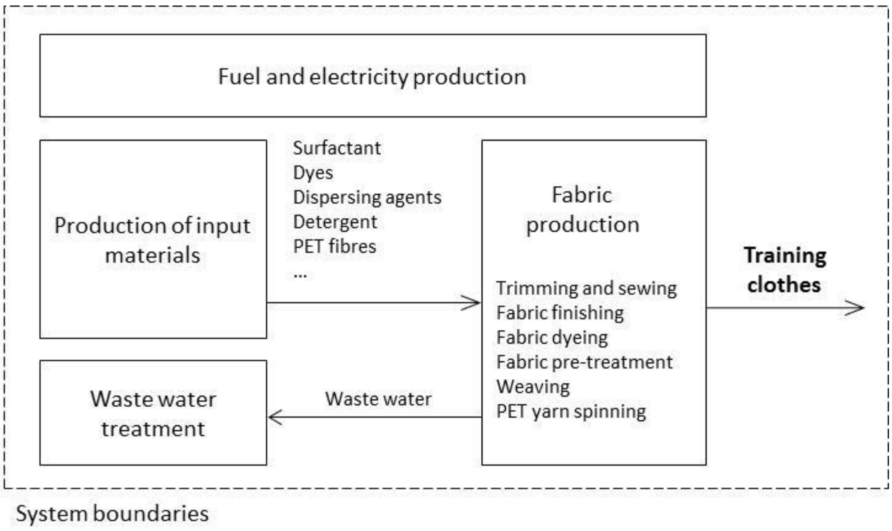

Figure 24 – System boundaries of the waste footprint analysis of training clothes

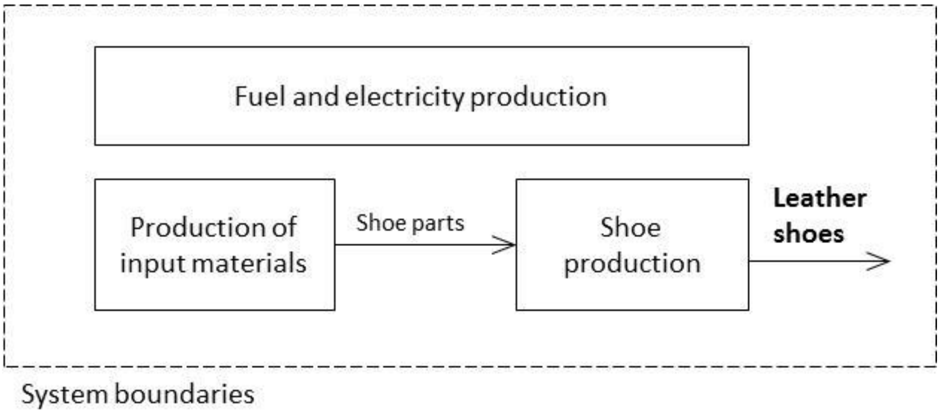

Figure 25 – System boundaries of the waste footprint analysis of a pair of leather shoes

Milk packaging and newspaper

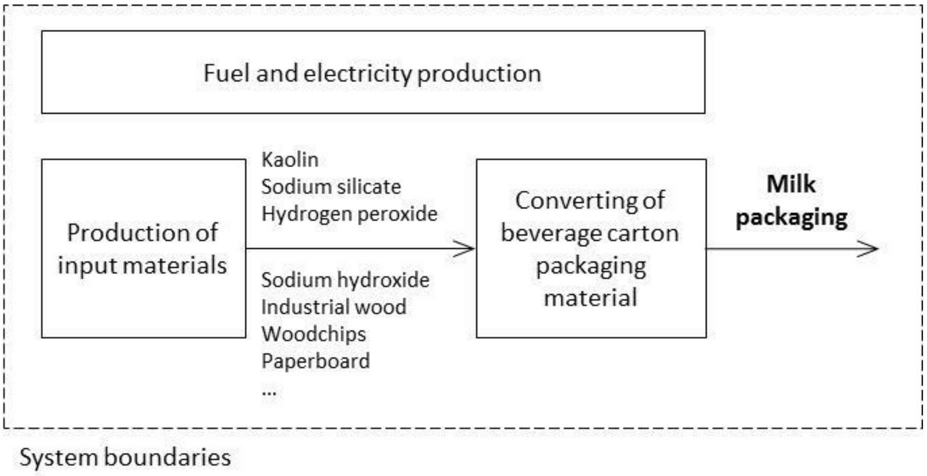

Figure 26 – System boundaries of the waste footprint analysis of milk packaging

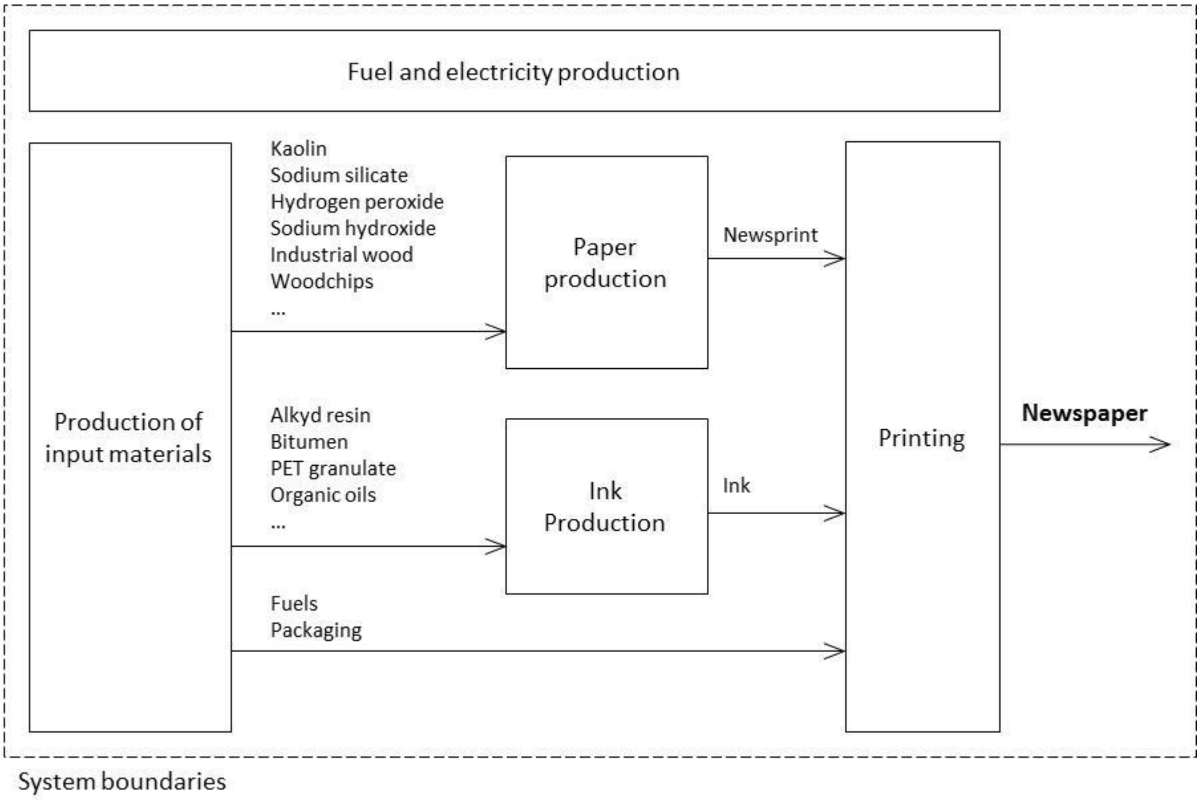

Figure 27 – System boundaries of the waste footprint analysis of a newspaper

Appendix 4 – Contribution of sources of wastes

Food

Table 9 - Contribution of sources of waste to the waste footprint of chicken meat

	Wastes from processing and input materials	Waste from fuel and electricity production
Feed production	40 %	0.5 %
Chicken farm	1.1 %	0.1 %
Slaughterhouse	58 %	0.2 %

Table 10 - Contribution of sources of waste to the waste footprint of beef

	Wastes from processing and input materials	Waste from fuel and electricity production
Farm management	<0.01 %	0.1 %
Feed production	6.3 %	0.1 %
Waste from slaughterhouse and meat processing	93 %	0.1 %

Table 11 - Contribution of sources of waste to the waste footprint of conventional milk

	Wastes from input materials	Waste from fuel and electricity production
Feed production	74 %	24 %
Dairy farm	1 %	1 %

Electro-electronic

Table 12 - Contribution of sources of waste to the waste footprint of an electric drill

Specification	Waste from mining and beneficiation	Fuel and electricity production
Product manufacturing	<0.01 %	<0.01 %
Aluminum	0.2 %	<0.01 %
Steel	19 %	0.5 %
Iron	0.2 %	<0.01%
Copper	80 %	<0.01 %
Plastic parts	0.1 %	<0.01 %

Table 13 - Contribution of sources of waste to the waste footprint of a laptop computer

Component	Waste from mining and beneficiation	Waste from fuel and electricity production
Lithium-ion battery	1.7 %	<0.01 %
Cables, plugs and adapters	3.5 %	<0.01 %
CD-ROM/DVD-ROM drive	4.9 %	<0.01 %
Hard disk drive	1.9 %	<0.01 %
LCD module	10 %	<0.01 %
Printed wiring boards	77 %	0.1 %
Computer casing	0.6 %	0.1 %

Table 14 - Contribution of sources of waste to the waste footprint of a smart phone

Specification	Waste from mining and beneficiation	Waste from fuel and electricity production
Battery unit	3.0 %	<0.01 %
Phone casing	0.6 %	0.1%
Glass	18 %	<0.01 %
Display	73 %	0.1%
Circuit boards	<0.01 %	<0.01 %
Plastic	3.0 %	<0.01 %
Cables, plugs and adapters	4.9 %	<0.01 %
Phone assembly	-	0.1%

Clothes and footwear

Table 15 - Contribution of sources of waste to the waste footprint of a pair of trousers

Composition	Waste from production of input materials	Waste from fuel and electricity production
Fabric	91 %	0.6 %
Cotton Bales	0.3 %	<0.01 %
Metal parts - brass (button, rivets and zipper)	7.6 %	<0.01 %

Table 16 - Contribution of sources of waste to the waste footprint of a t-shirt and shorts for training

Composition	Waste from production of input materials	Waste from fuel and electricity production
Fabric	98 %	0.7 %
PET fibres	1.5 %	<0.01 %

Table 17 - Contribution of sources of waste to the waste footprint of a pair of leather shoes

Components	Waste from input materials	Waste from fuel and electricity production
Adhesive and solvents	<0.01 %	<0.01 %
Insole	<0.01 %	<0.01 %
Lining	17%	0.1%
Laces	6.6%	<0.01 %
Sole	0.3%	0.1%
Upper and lining	35%	0.1%
Metal parts	39%	<0.01 %
Shoes production	0,7% (scrap loss)	0.1%

Milk packaging and newspaper

Table 18 - Contribution of sources of waste to the waste footprint of a milk packaging

Processes and composition	Converting - waste factory operation	Production of input materials	Fuel and electricity production
Converting	13 %	-	47 %
Packaging production	-	-	-
Paperboard	-	21 %	6.8 %
Printing ink	-	5.0 %	0.2 %
Plastic film (LDPE)	-	5.3 %	1.0 %
Opening (HDPE)	-	1.4 %	-

Table 19 - Contribution of sources of waste to the waste footprint of a newspaper

Process	Waste from production of input materials	Waste from fuel and electricity production
Paper production	26 %	9 %
Printing	59 %	3.7 %

IVL Swedish Environmental Research Institute Ltd., P.O. Box 210 60,S-100 31 Stockholm
Phone:+46-10-7886500 Fax: +46-10-7886590
www.ivl.se