LIFE CYCLE ASSESSMENT OF A PAPER FOOD CONTAINER

A report to Nordic Paper

2025-02-06

LIFE CYCLE ASSESSMENT OF A PAPER FOOD CONTAINER

Contact details

Name	Email	Telephone
Emil Svensson	emil.svensson@afry.com	+46722179893
Hanna Steinum	hanna.steinum@afry.com	+46722023946
Linnéa Termén	linnea.termen@afry.com	+46722370838

AFRY is an international engineering, design and advisory company. We support our clients to progress in sustainability and digitalisation. We are 19,000 devoted experts within the fields of infrastructure, industry and energy, operating across the world to create sustainable solutions for future generations.

AFRY Management Consulting provides leading-edge consulting and advisory services covering the whole value chain in energy, forest and bio-based industries. Our Sustainability Consulting team consists of 50+ experts who serve clients globally across all sectors. The team is part of a 1,300 people strong network of AFRY sustainability professionals worldwide.

SUMMARY

Nordic Paper is a global supplier of pulp and paper. Their products are used in various settings, one example is their greaseproof paper for food containers.

Nordic Paper has an interest in gaining more knowledge on the environmental performance through a Life Cycle Assessment (LCA) of a food container produced from Nordic Paper's greaseproof paper.

This report covers a cradle-to-grave LCA (excl use phase) of a food container produced in Sweden with greaseproof paper from Nordic Paper. The declared unit in this study is 1000 pieces of food container and the weight of one (1) food container is 4.5 g.

The food container is made of one raw material, greaseproof paper which is produced at the Nordic Paper Säffle site in Sweden. The production in the paper mill in Säffle consists of different process steps before the final paper product is delivered to the converter Tielman where the food container is converted. After conversion, the food container is distributed to consumers. At the End-of-life stage, it is assumed that the product is either recycled, incinerated or landfilled.

According to the assumptions made in this analysis, the result from the study shows that 1000 food containers produced with paper from Nordic Paper have a fossil climate impact of 5.2 kg CO_2-eq.

The environmental impact of the paper used in the food container could be reduced by using pulp from suppliers with lower environmental impact and by using chemicals that have a lower climate impact. It is also recommended to evaluate the possibility of changing the packaging material of the food containers before being distributed to consumers due to their high plastic content.

TABLE OF CONTENTS

TABLE OF FIGURES

1. INTRODUCTION

Nordic Paper is a global supplier of pulp and paper. Their products are used in various settings, such as their paper being used in the production of paper food containers. Nordic Paper was interested in gaining more knowledge on the environmental performance through a Life Cycle Assessment (LCA) of one type of food container which is made from Nordic Paper's greaseproof paper.

1.1 Introduction to Life cycle assessment (LCA)

Life Cycle Assessment (LCA) is a methodology for assessing the environmental impact of a product, service, or process. The LCA methodology is standardised according to ISO 14040 (ISO - International Organisation for Standardisation, 2006) and ISO 14044 (ISO - International Organisation for Standardisation, 2006) and consists of the steps Goal and scope definition, Inventory analysis, Impact assessment and Interpretation.

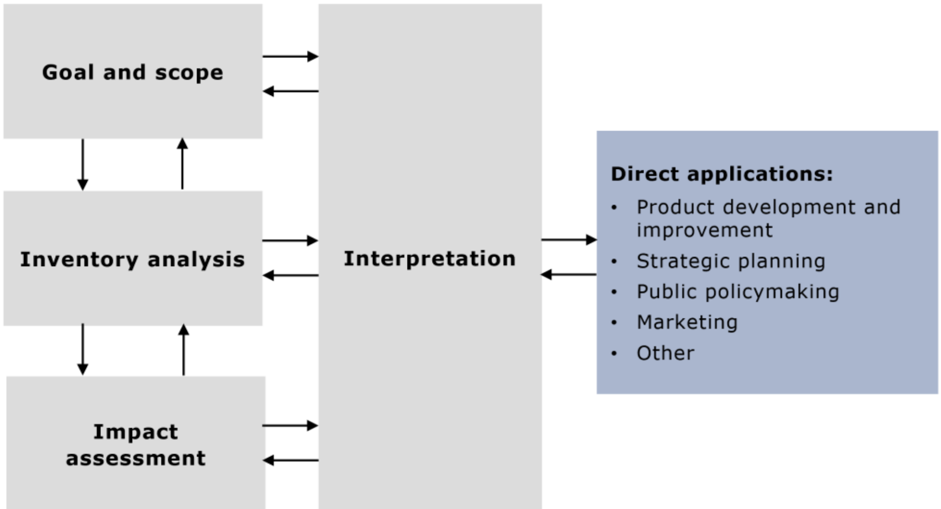


Figure 1: Framework for life cycle assessment (ISO - International Organisation for Standardisation, 2006).

1. Goal and scope definition: The goal of the study describes the intended application, the reasons for carrying out the study and the intended audience. The scope of the LCA is described with the product system being studied, the functional unit, the system boundaries, possible allocations, the methodology for environmental impact assessment and subsequent interpretation, limitations, data quality requirements, type of critical review if applied and type and format of report required for the study.
2. Inventory analysis: Information on materials and processes is collected including resources needed for and emissions and waste from each process. This is done for all phases in the product's life cycle.
3. Impact assessment: The environmental impact assessment evaluates the significance of the environmental effects that the product's life cycle

potentially contributes to. It is important to be aware that it is the potential environmental impact that is being described.

4. Interpretation: An interpretation of the results is made by, among other things, analysing the impact of the method choice and the underlying assumptions on the result. The significance of data gaps and used data quality must also be described in the interpretation section. The results of sensitivity analyses and uncertainty analyses performed in other parts of the study must appear in the interpretation.

Life cycle assessment is an iterative methodology meaning that the different phases of the study may need to be adjusted as the study is carried out and more information is collected.

A complete LCA comprises all phases of a product's life cycle ("cradle to grave") and includes extraction of raw materials, manufacture of materials, components and products, transport, use phase and waste management. It is also possible to only include a few life-cycle phases, the most common approach being a so-called cradle to gate-LCA, in which the assessment often ends after the manufacturing phase with the finished product ready to use.

When generating an LCA, the goal is to quantify environmental inputs and outputs to the defined system. Such inputs and outputs are, for instance, raw materials, different types of energy, water and emissions to air, soil, and water of different substances such as CO_2, NO_x, metals, and other pollutants.

Several emissions and resources used can contribute to the same environmental impact category. Therefore, resources and emissions are multiplied with so called characterisation factors to calculate the environmental impact in different categories such as climate change, eutrophication, resource use and toxicity. In this way, several resources and emissions contributing to environmental impact within a certain category can be added to or compared with each other. Resulting environmental impact is often expressed in "equivalents". One example is the impact category climate change in which other emissions contributing to climate change such as methane or nitrous oxide are recalculated to CO_2-equivalents.

2. GOAL AND SCOPE DEFINITION

2.1 Purpose of the study

The purpose of this study is to assess the environmental performance of the food container of greaseproof paper produced in Sweden by Nordic Paper and Tielman. The study is intended to be communicated externally to customers and stakeholders. This study will also be used internally at Nordic Paper in the process of developing products with a lower environmental impact.

2.2 Target audience

The target audience for this report is Customers, Stakeholders and Nordic Paper themselves.

2.3 Commissioner of the LCA Study and Other Influential Actors

The study is commissioned and fully financed by Nordic Paper. Nordic Paper and Tielman have also provided the data necessary for performing the study. LCA practitioners performing the study are employees at AFRY. AFRY do not have any conflict of interest in the execution of the study.

2.4 Product description

The product that is analysed in this LCA is a food container of greaseproof paper. The packaging material provides a good stability for food trays produced of the material. Further, the layer of Natural Greaseproof paper (Single Proof Golden) serves as a barrier against penetration of grease from the inside of the tray to the outside. In addition, the inner paper layer will also give a release function to baked goods as pies and quiches.

The specification for the food container can be seen in Table 1:

Table 1: The weight and dimensions of the product

Product	Weight (g)	Weight of paper
Food container of greaseproof paper	4.5	100-125 gsm

For a paper weight of 125 gsm, the food container will have a weight of 4.5 g.

The food container is made of one raw material, a greaseproof paper which is produced at the Nordic Paper Säffle site in Sweden. Raw materials used in the production of the greaseproof paper are either produced at Nordic Paper's other site, Bäckhammar in Sweden (the wood pulp) or sourced from European suppliers (wood pulp, chemicals, and other consumables). The production in the mill in Säffle consists of different process steps before the final paper product is delivered to the converter Tielman.

The greaseproof paper is converted to the food container at Tileman‘s site in Linköping, Sweden. The manufacturing of the food container consists of a few process steps before the final product is delivered to the customer.

The greaseproof paper is transported to the Tielman site in Linköping, Sweden where the conversion of the greaseproof to the food container takes place. The food container is then transported to the customer in Götene, Sweden. The system boundaries of the food container can be seen in section 2.7.

2.5 Declared Unit

The declared unit in this study is 1000 pieces of food container (with the weight of one container: 4.5 g), based on 125 gsm greaseproof paper, see Table 1.

2.6 LCI Modelling Framework

This study follows an attributional LCA framework following ISO 14040 (ISO - International Organisation for Standardisation, 2006) and ISO 14044 (ISO - International Organisation for Standardisation, 2006).

2.7 System Boundaries

The study is performed as a cradle-to-grave study, and for the food container, it includes the production of raw materials, transportation of raw materials to the production sites, production at both Nordic Paper’s and Tielman’s sites, distribution and waste management of the final product according to the system showed in Figure 2. The use phase of the product is thus not included in the study. Additionally, activities such as manufacturing of equipment, buildings and other capital goods are excluded as well as business travel and travel to and from work by personnel. However, background datasets may include capital goods in some cases.

In Figure 2, the general system boundaries of the study are shown. The system is divided into the modules:

- **Production of greaseproof paper at Nordic Paper’s site**: Including production and transport of raw materials, chemicals and production processes that are used in the production of greaseproof paper at Nordic Paper’s Säffle site.
- **Production of food container at Tielman’s site**: Including transport of raw materials and production processes that are used in the production and conversion of the food container at Tielman’s site.
- **Distribution and EoL (End-of-Life)**: Including transport to a distribution centre, transport to the final client and waste handling of the final product.

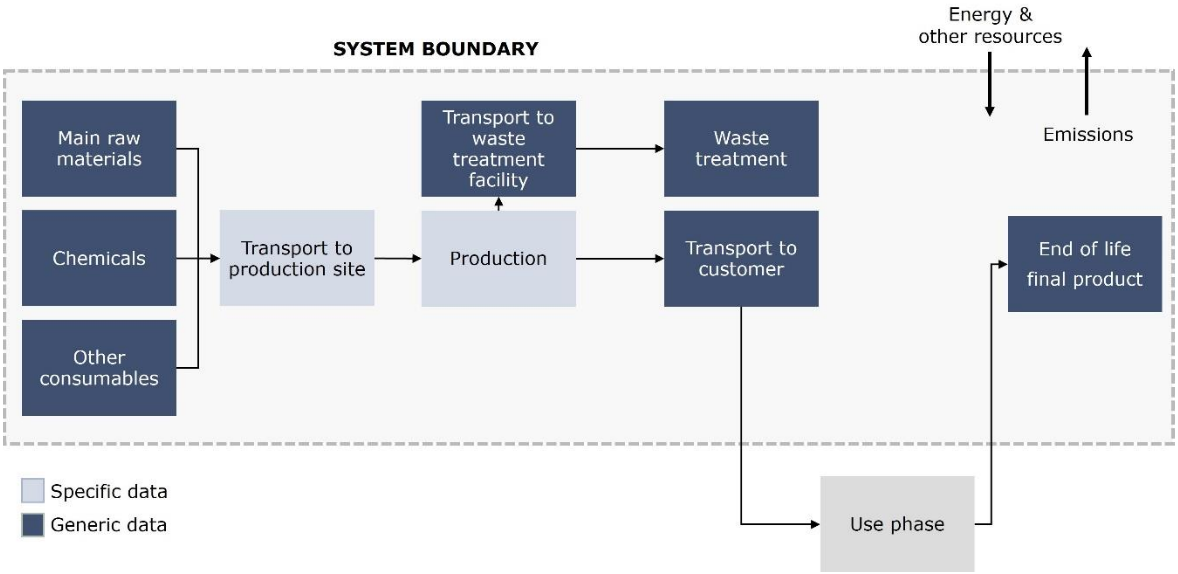


Figure 2: General system boundaries of the study

2.8 Cut-off criteria

All known mass and energy flows are included in the study.

2.9 Allocation

In the following section, the allocation choices related to the LCI analysis are presented.

An allocation has been done in relation to the produced greaseproof paper from Nordic Paper Säffle site. The production process at Säffle generates different kind of paper, where greaseproof paper is one of them. As this LCA study analyses the impact of the food container made from greaseproof paper, an allocation based on mass has been done.

2.9.1 Allocation of burdens between products

Allocation of manufacturing utilities, emissions and waste have been made as several products are produced in the same production site. Raw materials as pulp and the chemicals used for all paper production are also allocated. Natural greaseproof papers do not require other chemicals as input compared to non-greaseproof papers. This is because the greaseproof properties in this case comes from mechanical treatment and refining of the fibres. The allocation is made based on the total amount of paper produced.

2.9.2 Allocation of recycled content

Allocation of recycled materials has been set according to the polluter pays principle. This means that the generator of waste carries the full environmental impact until the point of the product’s life cycle at which the waste is transported to a waste disposal facility or the gate of a waste processing plant. The subsequent user of the waste shall carry the environmental impact from the processing and refinement of the waste but not the impact caused in the earlier life cycles. The greaseproof paper is used in products that has contact with food, therefore the paper can not contain any recycled material. However, the product produced by the greaseproof paper can go to recycling for waste management.

2.10 Software and database

The LCA model was created using Simapro software (v.9.6.0.1). Generic data comes primarily from Ecoinvent, 3.10 (Wernet, o.a., 2024). The geographical information of the data has been prioritized.

2.11 Representativeness of LCI Data

The quality level of the generic data used has been assessed according to the criteria from ISO 14044. The classification levels according to these criteria are for representativeness and coverageof the geographical, time-related, and technical representativeness of the datasets used in this analysis. The datasets were selected from Ecoinvent 3.10. In general, the overall representativeness of the data is good when the three criteria are assessed. In the following sub-sections, the data quality according to the three criteria is described.

2.11.1 Geographical Representativeness

The datasets used in the analysis have been chosen to best represent geographically where the production of the products takes place. If possible, datasets from the specific country where the production takes place have been chosen. The pulp produced in Bäckhammar is modelled with datasets from Sweden, whereas the rest of the suppliers of pulp are modelled with datasets from "Rest-of-Europe". The pulp accounts for the largest share of the total raw material used in the production of greaseproof paper.

For the modelling of the electricity for the food container, a Swedish average electricity mix from Ecoinvent was used as a starting point and modified according to specific information on electricity used during the production. If datasets were not available on materials or processes in the right geography, regional datasets, such as "Rest-of-Europe", "Global", or "Rest-of-World" were used instead. This is also the case for the chemicals used in the production, for which global generic datasets have been used.

2.11.2 Time-Related Representativeness

The time-related representativeness of the data is considered good. All specific inventory data is from the year 2023 and is based on production data for the entire year. The generic data was based on Ecoinvent version 3.10 (Wernet, o.a., 2024) which was released in Mars 2024.

2.11.3 Technical Representativeness

Datasets representing the stated technology were selected from Ecoinvent 3.10 (Wernet, o.a., 2024). In cases where the technology was unknown or uncertain, datasets representing an average or conventional method were prioritised. This is the case for modelling the chemicals and additives used during the production, where organic and inorganic chemicals were used to represent the unknown chemicals. Alternatively, datasets for similar product types or more general datasets were utilised.

2.12 Impact Assessment Method

In this study, the impact categories climate change, climate change – fossil, climate change – biogenic, climate change – Land use and LU change, acidification potential, resource use, particulate matter have been assessed. The rationale for choosing these categories is that they are pointed out as the most relevant for intermediate paper products in PEFCR (European Commission, 2020). Water use was also assessed in addition to the categories mentioned above. Even though the food container is not an intermediate product, these impact categories have been considered relevant also for that product since pulp and paper production is the dominant production process.

Impact assessment categories from EF 3.1 as implemented in SimaPro have been used.

Table 2 shows impact categories. Characterisation factors for the included impact categories can be found on the European Platform on Life Cycle Assessment (European Commission, 2019).

Table 2: Environmental impact categories from EN 15804:2012 + A2:2019

Impact category	Indicator	Unit	Model
Climate change - total	Radiative forcing as global warming potential (GWP100)	kg CO2eq.	Baseline model of 100 years of the IPCC based on IPCC 2021
Climate change - fossil	Global Warming Potential (GWP-fossil)	kg CO2eq.	Baseline model of 100 years of the IPCC based on IPCC 2021
Climate change - biogenic	Global Warming Potential (GWP-biogenic)	kg CO2eq.	Baseline model of 100 years of the IPCC based on IPCC 2021
Climate change – land use and land use change	Global Warming Potential (GWP-luluc)	kg CO2eq.	Baseline model of 100 years of the IPCC based on IPCC 2021
Acidification	Acidification potential, Accumulated Exceedance (AP)	mol H+ eq.	Accumulated Exceedance, Seppälä et al. 2006, Posch et al., 2008
Resource use, fossils	Abiotic resource depletion – fossil fuels (ADP-fossil)	MJ, net calorific value	CML 2002, Guinée et al., 2002, and van Oers et a. 2002.
Particulate matter emissions	Potential incidence of disease due to PM emissions (PM)	Disease incidence	SETAC-UNEP, Fantke et al. 2016
Water use	User deprivation potential (deprivation-weighted water consumption)	m3 world eq.	Available WAterREmaining (AWARE) Boulay et al., 2016

2.13 Limitations

This study should not be used to make general claims on whether the products are environmentally friendly or not. The LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. The quality of the results depends on the quality of the LCI given by Nordic Paper and Tielman, and on the quality of the datasets used.

2.14 Critical Review

As this report is to be communicated externally, an independent third-party review is to be performed. This review is done by Miljögiraff. In addition, AFRY assigns an internal quality reviewer to all its projects.

3. LIFE CYCLE INVENTORY ANALYSIS

In the following section the methodological choices related to the LCI-analysis are presented.

3.1 Data Collection

Inventory data has been collected from the companies Nordic Paper and Tielman. All specific inventory data is from the year 2023 and is based on production data for the entire year. Data connected to the production at Nordic Paper's and Tileman's facilities, and transportation of raw materials is specific while data for raw materials, waste transport and management, transport to customers and EoL are generic. Generic data comes from Ecoinvent 3.10 (Wernet, o.a., 2024). The energy use, amount of waste, chemicals and direct emissions have been allocated to the product by mass.

3.2 System Modelling food container

The system modelling of the food container has been divided into three modules: 1) Production of greaseproof paper at Nordic Paper's site, 2) Production of food container at Tielman's site, and 3) Transport to customer and EoL of the final product. The system modelling and input and output for the food container will be presented in the following sections.

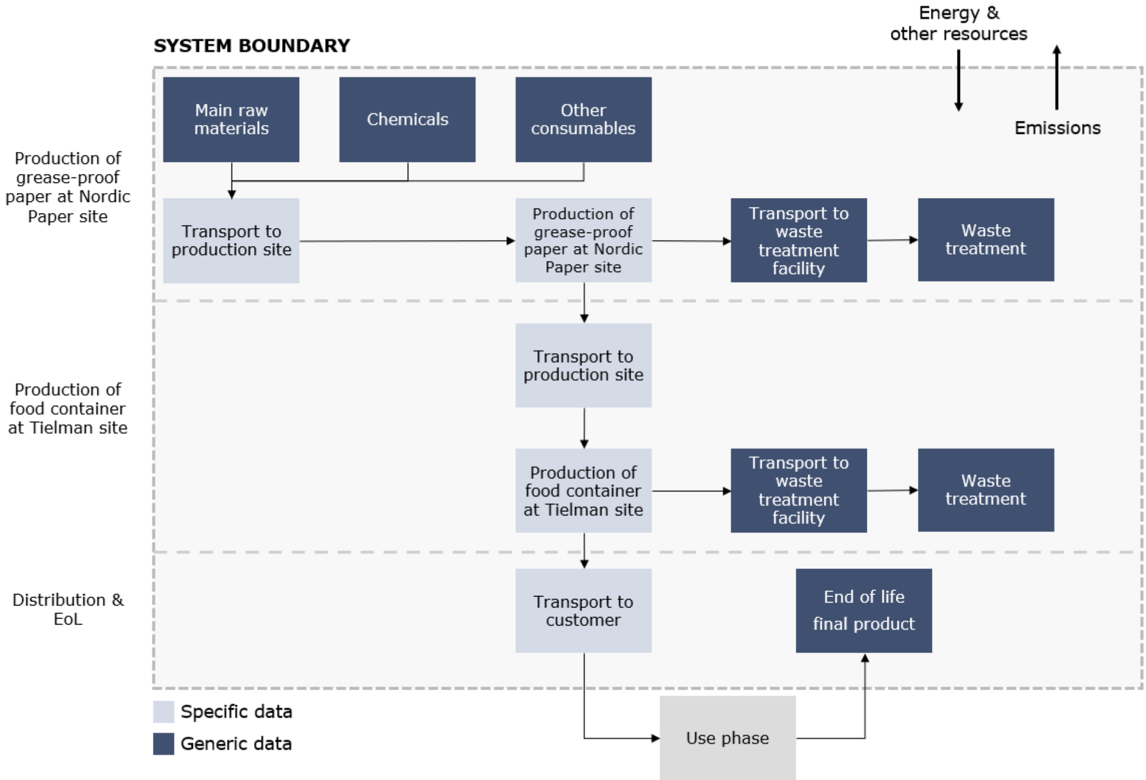


Figure 3: System model

3.2.1 Production of greaseproof paper at Nordic Paper site

The *Production of greaseproof paper at Nordic Paper site* module includes the raw materials (along with transport to the manufacturing facility), chemicals and other consumables used in production and the production processes at Nordic Paper's Säffle site. Nordic Paper has shared comprehensive information on their environmental impact, including data on their emissions, energy use, chemical usage, water consumption, waste generation and transportation. The data also covered waste generated through spillage during production, as well as chemicals used in the different process stages. The following sections explain the generic data modified for this specific study, as well as explain the thought process for the system modelling done in Simapro.

The full life cycle inventory (input and output data as well as used generic datasets) for the production at the Nordic Paper Säffle site can be found in **Error! Reference source not found.**.

3.2.1.1 Raw materials

The main raw materials used in the production of greaseproof paper are pulp from different suppliers.

The pulp that is used in the production of greaseproof paper is bleached sulfate pulp from eucalyptus, bleached sulfate pulp from softwood, unbleached sulfate pulp from softwood and bleached sulfite pulp. Generic data sets for pulp are used for the system modelling with the Rest-of-Europe as geographical boundary. The data set for all pulp supplies is included with the transport of a freight lorry.

3.2.1.2 Chemicals

The safety data sheets of the chemicals were provided by Nordic Paper. Searches online were then used to gain information on the specific data on the substances in the chemicals.

For the data sheets that disclosed very small amounts of the substances in the chemicals, generic data sets from Ecoinvent (either organic or inorganic chemicals) were used to model those chemicals.

3.2.1.3 Energy and water use

Electricity

Nordic Paper's manufacturing facility in Säffle both self-produces electricity from incineration of wood chips, and purchases electricity from the company Vattenfall, which generates electricity from different sources.

For the purchased energy from Vattenfall, the share of the different sources has been provided by the company, with the largest source in the electricity mix being nuclear energy with 61% share, followed by hydro energy with 39% share. Swedish average electricity mix from Ecoinvent was used as a starting point during the system modelling for the electricity and has been modified according to Vattenfall's electricity mix that Nordic Paper purchases. The certificate of origin can be found in **Error! Reference source not found.**.

Water

The water used at the Nordic Paper Säffle site comes from a nearby lake.

3.2.1.4 Packaging

The produced greaseproof paper is rolled up and packaged with a wrapping paper which is a PE-laminated wrapping paper. The short sides of the rolls are then covered with dishes made from kraft paper.

The wrapping paper consists of 11% PE plastic and 89% paper.

3.2.1.5 Transport

Transport distances for raw materials were provided by Nordic Paper. Raw materials from Europe are transported by truck, train or boat. In **Error! Reference source not found.** the distances, transport types and data sets are presented.

3.2.1.6 Direct emissions (to air and water)

The direct emissions stemming from the production of Nordic Paper's greaseproof paper were provided by Nordic Paper and are the direct emissions (to air and water) registered at Naturvårdsverket for the year 2023. The direct emissions can be found in **Error! Reference source not found.**.

3.2.1.7 Manufacturing waste

Waste from the manufacturing process is divided into hazardous and non-hazardous waste and sent to waste treatment processes. Based on information from Nordic Paper, the waste goes to incineration or recycling. The amounts of manufacturing waste, as well as the respective waste treatment methods can be found in **Error! Reference source not found.**.

A transport distance of 110 km with truck for non-hazardous waste, and a transport distance of 118 km for hazardous waste was added to the model.

3.2.2 Production at Tileman site

The *Production at Tielman site* module includes the raw materials (along with transport to the manufacturing facility), and the conversion processes of the food container at Tielman's site. Tielman has shared comprehensive information on their environmental impact, including data on energy consumption, waste generation and transportation. The data also cover waste produced through spillage during production.

The following sections explain the generic data used in this specific study, as well as explain the thought process for the system modelling done in Simapro.

The full life cycle inventory (input and output data) for the production at Tielman's site can be found in **Error! Reference source not found.**.

3.2.2.1 Raw material

The only raw material to produce the food container is greaseproof paper from Nordic Paper.

3.2.2.2 Transport

Transport distances for the raw material were provided by Tielman. The raw material is transported by truck. In **Error! Reference source not found.** the distances, transport types and data sets are presented.

3.2.2.3 Energy - Electricity

The manufacturing facility in Linköping purchases electricity from the company Vattenfall, which provides an electricity mix from hydropower. The certificate of origin can be found in **Error! Reference source not found.**.

3.2.2.4 Packaging

The produced food containers are packed in plastic bags. The bags are stacked on steel pallet containers EUR and wrapped in plastic packaging film before they are shipped to the customer.

3.2.2.5 Direct emissions

There are no direct emissions stated by the converter of the food container.

3.2.2.6 Manufacturing waste

Waste from the manufacturing process is non-hazardous waste and it is sent to waste treatment processes. Based on information from Tielman, the waste is assumed to go to recycling. An average transport distance of 4 km with a truck was added to the model.

3.2.3 Distribution and End of Life

3.2.3.1 Distribution

The distribution of the food container is divided into two steps. The first step is from the converter (Tielman) to the first customer which is a client in Götene. The second step is from the client in Götene to the final client.

In this study, the first distance is assumed to be on average 240 km and the second distance on average 500 km. All transports are assumed to be by road.

3.2.3.2 End-of-Life

The end-of-life scenario for the food container includes recycling, incineration and landfill. It is assumed that the end-of-life scenario takes place in Sweden and the share for the different processes is presented in Table 3.

Table 3: End-of-life scenario for the product

Process	Percentage	Comment
Recycling	78%	(Förpackningsinsamlingen, 2023)
Incineration	21.4%	Split between energy recovery and landfill, based on 2022 Avfallshantering (Avfall_Sverige, 2023)
Landfill	0.6%	Split between energy recovery and landfill, based on 2022 Avfallshantering (Avfall_Sverige, 2023)

4. RESULTS AND INTERPRETATION

The estimated impact results are only relative statements which do not indicate the endpoints of the impact categories, exceeding threshold values, safety margins or risks.

4.1 LCIA results for the food container

In Table 4, the LCIA results for the following impact categories for the food container are presented.

Table 4: LCIA results per 1000 food containers (weighing 4.513 g per food container)

Impact category	Unit	Production of greaseproof paper at Nordic Paper site	Production of food containers at Tielman site	Distribution and EoL	Total
Climate change – Fossil	kg CO_2 eq	2.79E+00	1.38E+00	1.07E+00	5.24E+00
Climate change – Biogenic[1,3]	kg CO_2 eq	-2.27E+00	-1.65E-02	1.56E+00	-7.35E-01
Climate change – Land use and LU change	kg CO_2 eq	5.50E-02	7.29E-03	3.54E-04	6.26E-02
Climate change (total)[1]	kg CO_2 eq	5.70E-01	1.38E+00	2.63E+00	4.57E+00
Acidification	mol H+ eq	2.27E-02	5.14E-03	2.71E-03	3.06E-02
Resource use, fossils[2]	MJ	1.67E+02	3.05E+01	1.48E+01	2.12E+02
Water use[2]	m^3 depriv.	2.37E+00	6.70E-01	9.61E-02	3.14E+00
Particulate matter	disease inc.	3.56E-07	6.84E-08	8.39E-08	5.08E-07

[1] Note that results for climate change-biogenic and climate change-total include CO_2 taken up by trees while growing and stored in paper. This CO_2 will eventually be released back into the atmosphere. Thus, results in these impact categories shall be used with care.

[2] The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience with the indicator.

[3] Biogenic emissions are based on the carbon content in the product (1.98 kg C/1000 food containers). The End of Life (EoL) is adjusted according to this value.

4.1.1 Environmental impact of the different life cycle stages

Figure 4 shows the relative environmental impact of 1000 food containers, for the following environmental impact categories: climate change – total, climate change – fossil, climate change – biogenic, climate change – land use and LU change, acidification, resource use - fossil, water use and particulate matter. The results are shown according to the three modules presented above. Climate change (total) is the sum of the other three climate change categories (Land use and land use change, biogenic and fossil).

In this analysis, a decision was made to focus on the fossil climate impact to avoid creating confusion for the reader. The rationale for this decision is that trees which are the main raw material for paper absorb biogenic carbon when they grow. This carbon is then stored in the containers and finally emitted into the atmosphere when the food containers are incinerated. As we in this study are looking at different end-of-life scenarios, including recycling that does not lead to a release of biogenic carbon, we want to avoid the impression that food containers are carbon sinks by focusing on fossil impact and not the total climate impact.

The figure shows that the highest impact is connected to the raw material production for all the categories. The second highest impact for climate change fossil is connected to the production at the Tielman site, with the highest contributor being the packaging of the food containers.

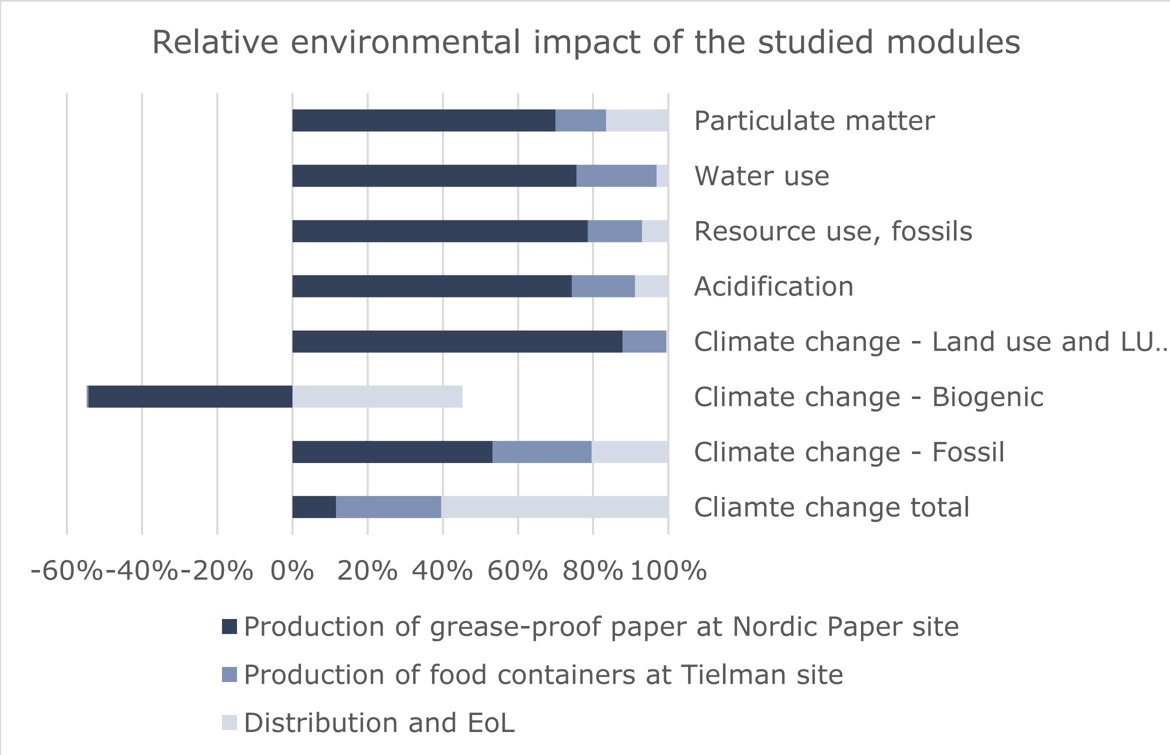


Figure 4: Environmental impact of life cycle modules for the full inventory

4.1.2 Climate change – fossil

This section presents the impact category of Climate change – fossil.

Figure 5: Fossil climate impact from the three Figure 5 shows the fossil climate impact for the three different modules. This figure shows that the greaseproof paper has the highest impact of these three. In the following sections, the fossil climate impact from the modules will be analysed further.

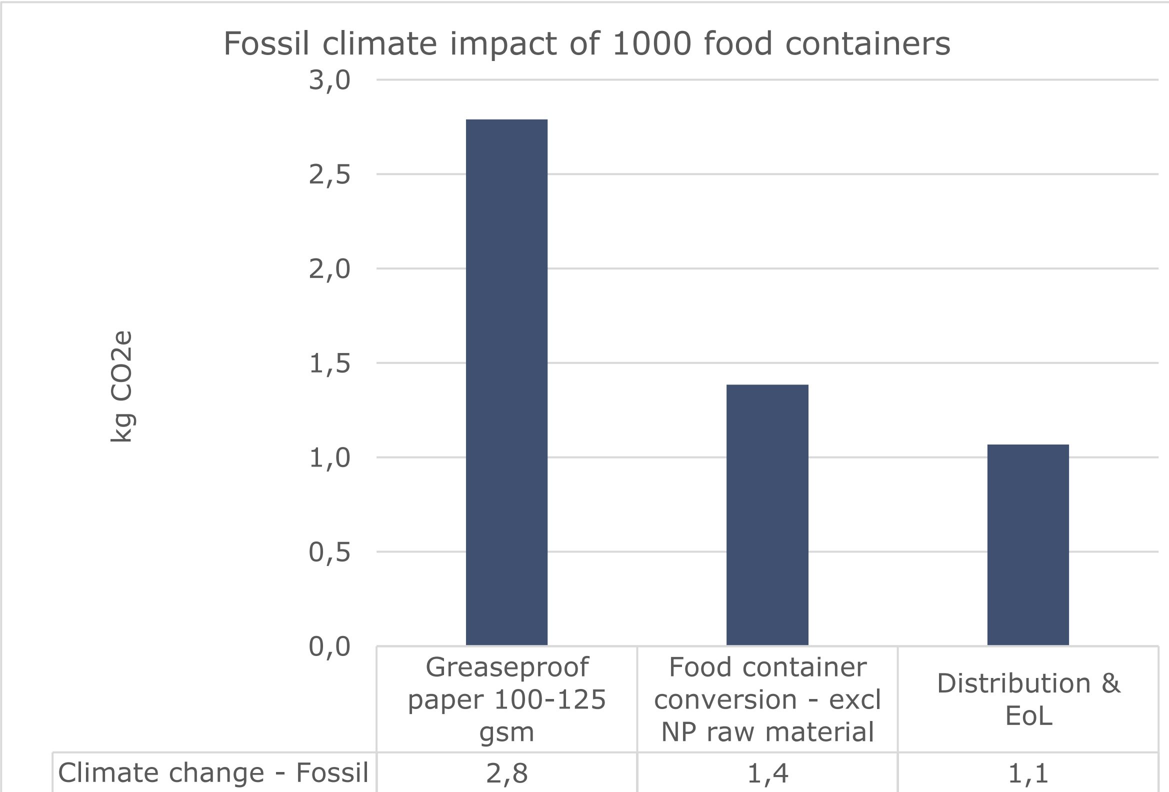


Figure 5: Fossil climate impact from the three modules

4.1.2.1 Production at Nordic Paper

This section presents the fossil climate impact from the module *Production of greaseproof paper at Nordic Paper site* to produce 1000 food containers. The results are shown according to the production of 5.429 kg of Nordic Paper's greaseproof paper 100-125 gsm, which is the amount needed for the production of 1000 food containers. In **Error! Reference source not found.**, the results for production of 1 tonne of Nordic Paper's crease proof paper 100-125 gsm are presented.

Figure 6 shows the results for climate change fossil for the production of greaseproof paper with the highest contributing impact allocated to the raw material, followed by the production. The reason why the raw material has the highest impact is due to the production of the pulp which is an energy-intensive process.

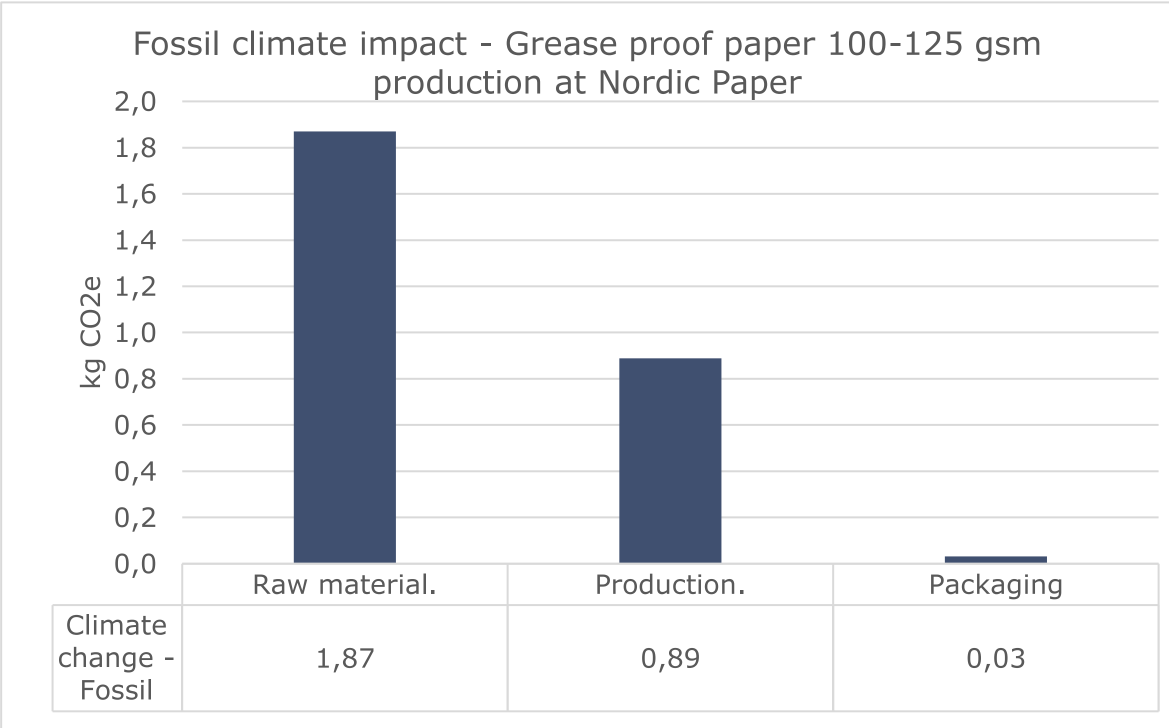


Figure 6: Fossil climate impact for the production of 5.429 kg of greaseproof paper

4.1.2.2 Production at Tielman

This section presents the fossil climate impact from the module *Production of food containers at Tielman site* to produce 1000 food containers. The results do not include the raw materials connected to the manufacturing of Nordic Paper's greaseproof paper. The weight of one food container is 4.5 g, and the fossil climate impact is shown in kg CO_2-eq.

Figure 7 shows the results according to the manufacturing process. The results show that for the manufacturing at the Tielman site, it is the packaging process that has the highest impact on climate change fossil due to the plastic film that is used in this manufacturing step.

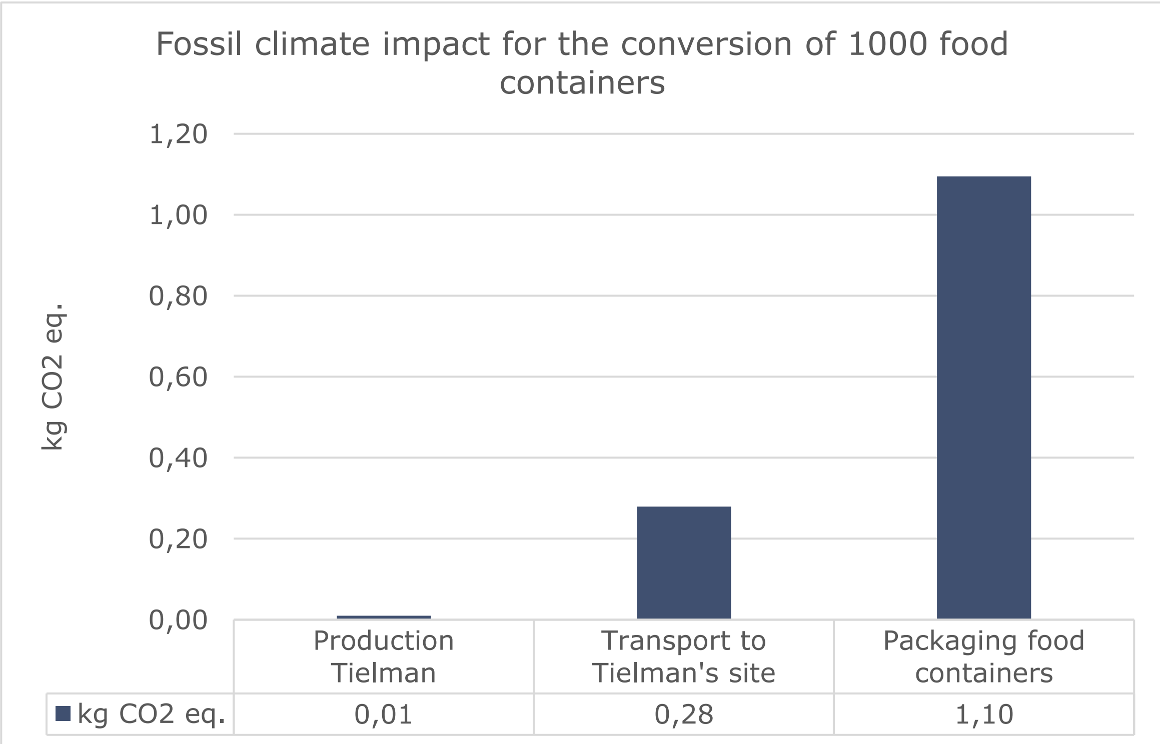


Figure 7: Fossil climate impact to convert 1000 food containers

4.1.2.3 Distribution & EoL

This section presents the fossil climate impact from the module *Distribution and End-of-life* for the food container.

Figure 8 shows the results according to the distribution process and the EoL process. The figure shows that the transportation during the distribution, and the EoL, have the largest impact of these two processes. That is due to the combustion of fossil fuels during the transport by road.

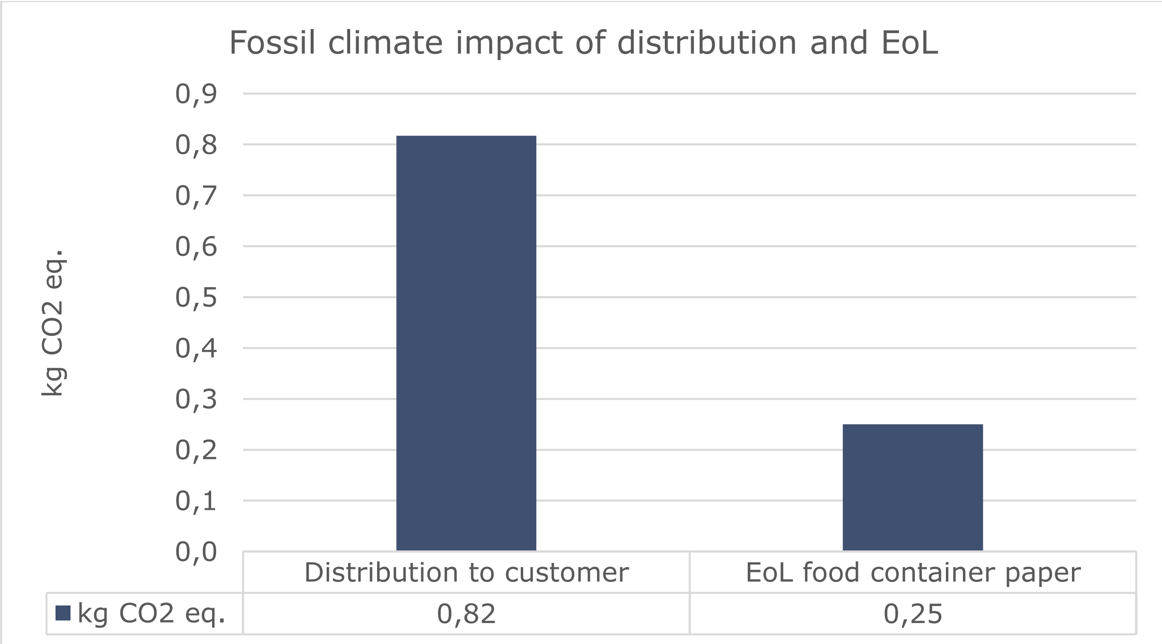


Figure 8: Fossil climate impact of distribution and EoL

5. SENSITIVITY ANALYSIS

A sensitivity analysis can be made to study the effects of certain modelling assumptions, or the effects of certain design/production/purchasing choices on the product's environmental performance. In the following section, the effects corresponding to the following scenarios are presented in more detail:

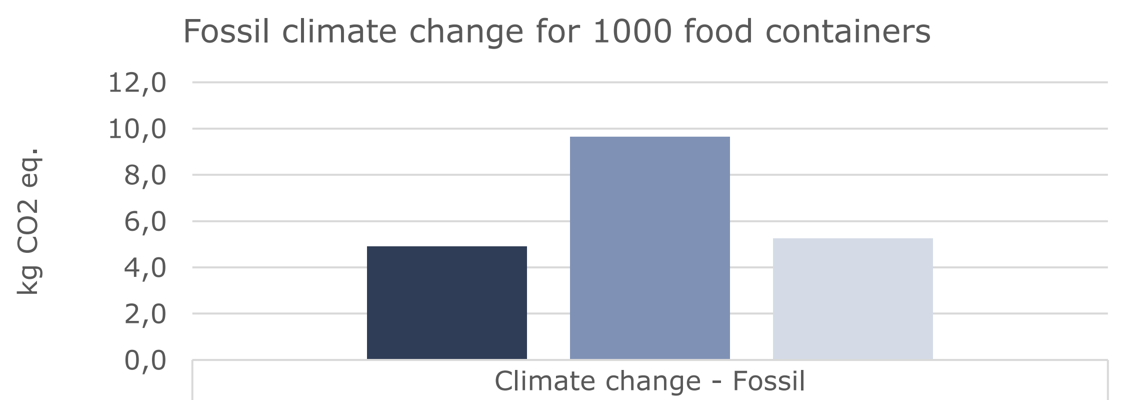
- Scenario 1 – The pulp comes from one supplier (best and worst) scenario.
- Scenario 2 – EoL of the food container is only incineration.

These scenarios have been chosen as interesting scenarios to analyse further as raw materials and EoL have a major impact on the entire life cycle when it comes to fossil climate impact and therefore different scenarios for those parts have been investigated.

5.1 Change of raw material supplier

The change in raw material suppliers' scenarios is compared to the base case. The new cases assume that the raw material supplier is the best or worst, from a fossil climate change perspective, for the food container.

The results can be seen in Figure 9. The figure shows the total fossil climate impact of the total life cycle for the food container. In this study, the best case is represented by unbleached sulfate pulp, and the worst case is by bleached sulfite pulp. There is a small change, but it is not significant, in the impact of fossil climate change when the base case is compared to the best case. However, when the base case is compared to the worst case, the change in fossil climate impact is larger, almost double.



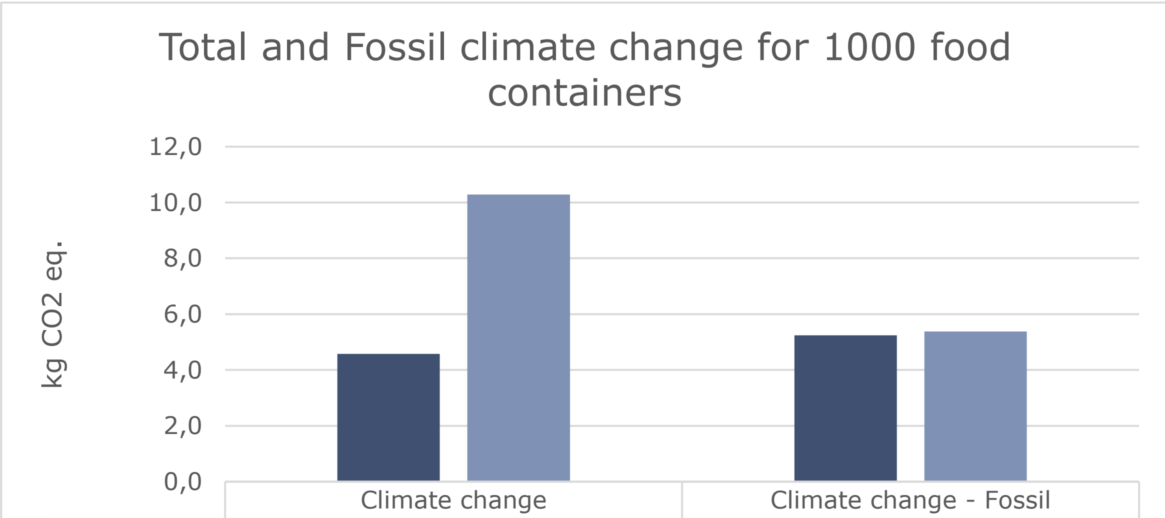
	Climate change - Fossil
Best	4,9
Worst	9,6
Base case	5,2

Figure 9: Fossil climate change for 1000 food containers

5.2 Other End-of-life scenarios for the food container

The other EoL scenarios are compared to the base case. The new case assumes that the end-of-life for all the food containers will be incinerated, compared to the base case where 78% goes to recycling, 21.4% to incineration and 0.6% to landfill.

The results can be seen in Figure 10. The figure shows both the total climate impact and the total fossil climate impact of the total life cycle for the food container. There is a small change in the impact of fossil climate change in the different cases, but it is not significant. However, for the total climate impact, the change is larger, about twice as large. This is due to the biogenic carbon in the product being emitted during the incineration.



	Climate change	Climate change - Fossil
Base case	4,6	5,2
Incineration	10,3	5,4

Figure 10: Total and Fossil climate change for 1000 food containers

6. CONCLUSIONS AND RECOMMENDATIONS

In this chapter the conclusions and recommendations from this study are presented. When interpreting the results of the study, it is important to consider the underlying assumptions and restrictions associated with both the methods and data used.

The analysis focuses on fossil climate impact to avoid misinterpretation caused by the biogenic carbon cycle inherent to paper-based products. This ensures the study does not mistakenly portray food containers as carbon sinks.

The production of raw materials to the greaseproof paper is the most significant contributor to environmental impact for all assessed categories. For fossil climate impact, this is primarily driven by the energy-intensive process of pulp production used in manufacturing of the paper. In the food container manufacturing phase at the Tielman site, the packaging process is identified as the largest contributor due to the use of plastic film.

The recommendation in accordance with the results and conclusions is that an effort should be made to decrease the climate impact of the raw material that is used in the production of the greaseproof paper. Nordic Paper should consider an evaluation of the suppliers of pulp to lower the overall climate impact of its products. The same recommendation is given for the use of chemicals in the production, even if these impacts are not as high as the pulp production impacts.

It is also recommended to evaluate the possibility of changing the packaging material of the food containers before being distributed to consumers. When the product is being distributed to end consumers the factor depends on the final location of the food container, where longer distances could result in a higher climate impact compared to shorter distances, which could result in a smaller climate impact.

REFERENCES

Avfall_Sverige. (den 30 06 2023). *2022 Svensk avfallshantering.* Hämtat från Avfall Sverige Avfallsstatistik: https://www.avfallsverige.se/media/whafyutn/svensk_avfallshantering_2022.pdf

European Commission. (2019). *European Platform on Life Cycle Assessment* . Hämtat från https://eplca.jrc.ec.europa.eu/LCDN/EN15804.xhtml den 25 10 2021

European Commission. (2020). *Product Environmental Footprint (PEF) Category Rules (PEFCRs) - Intermediate paper products. Version 2.0.* Hämtat från https://ec.europa.eu/environment/eussd/smgp/PEFCR_OEFSR_en.htm

Förpackningsinsamlingen, F. (den 07 12 2023). *Statistik*. Hämtat från FTI: https://fti.se/om-fti/statistik

ISO - International Organisation for Standardisation. (2006). *Environmental management - life cycle assessment - principles and framework. International Standard ISO 14040.* Geneva.

ISO - International Organisation for Standardisation. (2006). *Environmental management - life cycle assessment - requirements and guidelines. Internationa Standard ISO 14044.* Geneva.

Termén, L., Pálmarsdóttir, J. W., & Fransson, K. (2024). *LIFE CYCLE ASSESSMENT OF A PAPER E-COMMERCE BAG.* Gothenburg: AFRY.

Wernet, G., Bauer, C., Steubing, B., Reinhard, J., Moreno-Ruiz, E., & Weidema, B. (2024). The ecoinvent database version 3 (part I): overview and methodology. *The international journal of Life Cycle Assessment*, 1218-1230.

QUALITY AND DOCUMENT CONTROL

Quality control

Role	Name	Date
Author(s):	Linnéa Termén Hanna Steinum	2025-02-06
Approved by:	Emil Svensson	2025-02-06
QC review by:	Emil Svensson	2025-02-06

Document control

Version no.	Principal changes	Date
v.1	Initial client release	2025-02-06

AFRY IS AN INTERNATIONAL ENGINEERING, DESIGN AND ADVISORY COMPANY.

We support our clients to progress in sustainability and digitalisation. We are 19,000 devoted experts within the fields of infrastructure, industry and energy, operating across the world to create sustainable solutions for future generations.

AFRY Management Consulting provides leading-edge consulting and advisory services covering the whole value chain in energy, forest and bio-based industries. Our Sustainability Consulting team consists of 50+ experts that serve clients globally across all sectors. The team is part of a 1,300 people strong network of AFRY sustainability professionals worldwide.

AFRY Management Consulting
Grafiska vägen 2
Box 1551
SE-40151 Gothenburg
Sweden

Tel: +46 10 505 00 00
afry.com

AFRY Management Consulting AB
Registered office in Stockholm
Corp. id: 556850-0515
VAT: SE556850-0515