CLIMATE IMPACT FROM

Nordic Swan Ecolabelled Candles

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Elin Einarson Lindvall and Katarina Lorentzon (P118517)

Photo: Mercedes B on Unspash


Photo: Prateek from Unsplash

Content

Background

- The Nordic Swan Ecolabel has criteria that among other things aim to reduce the climate impact from products and services, both directly and indirectly. RISE was contacted with a request for support to strengthen criteria work in the climate area, applied in the specific case of ecolabelled candles.
- The request concerns a screening of the opportunities to make the reduced climate impact from ecolabelled products visible, using candles as case.
- There are previously simplified calculations of climate benefits for the ecolabelled candles. RISE was asked to make more extensive calculations.

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Executive summary

Summary 1(2)

The goal of this study is to calculate and compare the climate impact from a Nordic Swan Ecolabelled candle (90% stearin, 10% paraffin) and a conventional candle from 100% paraffin. Stearin is of biogenic origin and generate biogenic CO_2 when burning. Paraffin is of fossil origin and generate fossil CO_2 when burning.

Two Nordic Swan ecolabelling criteria for candles have been in focus: the *requirement O2*, stating that the amount of renewable raw material in the candle must exceed 90 % of the total weight, and the *requirement O3*, stating that vegetable raw materials from palm and soy oil must not be used. The method used is life cycle assessment (LCA), evaluating only one impact category, namely climate impact, mainly based on SS-EN ISO14067 (2018).

Since energy content per kg candle differ slightly between paraffin and stearin, two functional units have been used: 1 kg candle and 1 MJ candle.

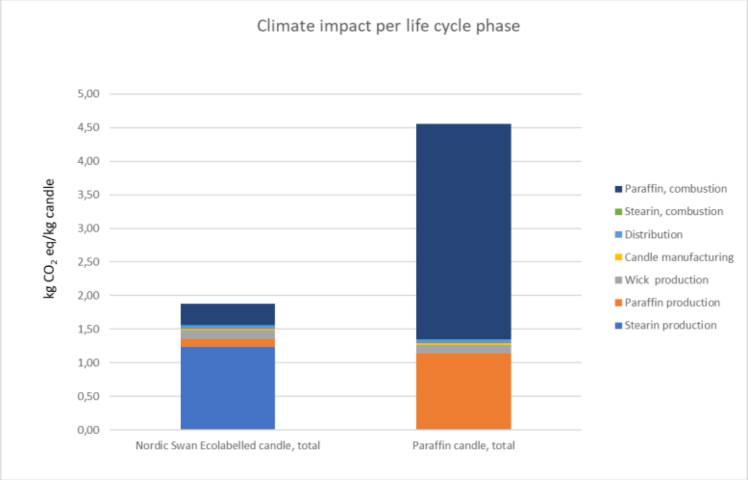
The system includes production of raw material, candle manufacturing, transports in between these and to retail and, finally, burning of candles. However, processing of cotton yarn to produce the wick and combustion of it, storing of candles (distribution centers, retail), and transport from retail to customer are excluded. Furthermore, the entire candle is burned (i.e. no waste treatment is included).

The assessment makes use of average data (attributional LCA), representing candles manufactured in Sweden and consumed in Stockholm. The assessment method is Climate change, EF 3.0 in SimaPro 9.5.0.0 (GWP 100, based on IPCC, 2013).

Summary 2(2)

The GHG emissions and removals from Nordic Swan Ecolabelled candle consist of equal amounts of biogenic emissions and removals, less fossil emissions and minor contributions from land use and land use change. The GHG emissions and removals from the conventional candle consist of almost exclusively fossil emissions.

Both considering weight and energy content, the climate impact is lower (approximately 55-60 %) for the Nordic Swan Ecolabelled candles than for paraffin candles. Combustion of paraffin is the hot spot for paraffin candles. The climate impact from combustion of the Nordic Swan Ecolabelled candle are significantly lower due to the mainly renewable raw material.



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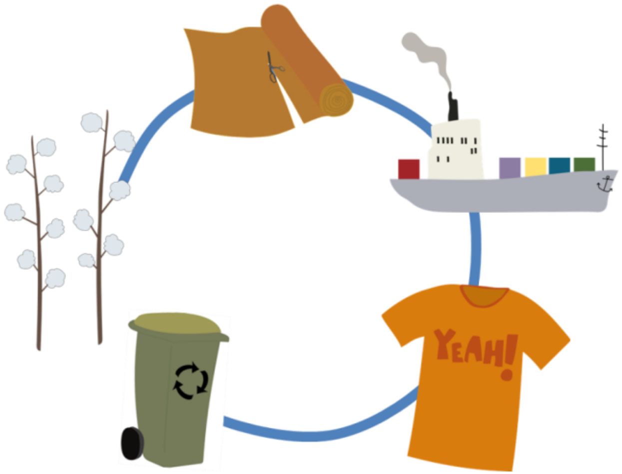
LCA-methodology

Life Cycle Assessment

Life Cycle Assessment is a methodology to quantify the environmental impact from the entire lifecycle of a product. From raw material extraction and acquisition, through energy and material production and manufacturing to use, end of life treatment and final disposal.



ISO 14040/-44 (2006)

Four phases of an LCA

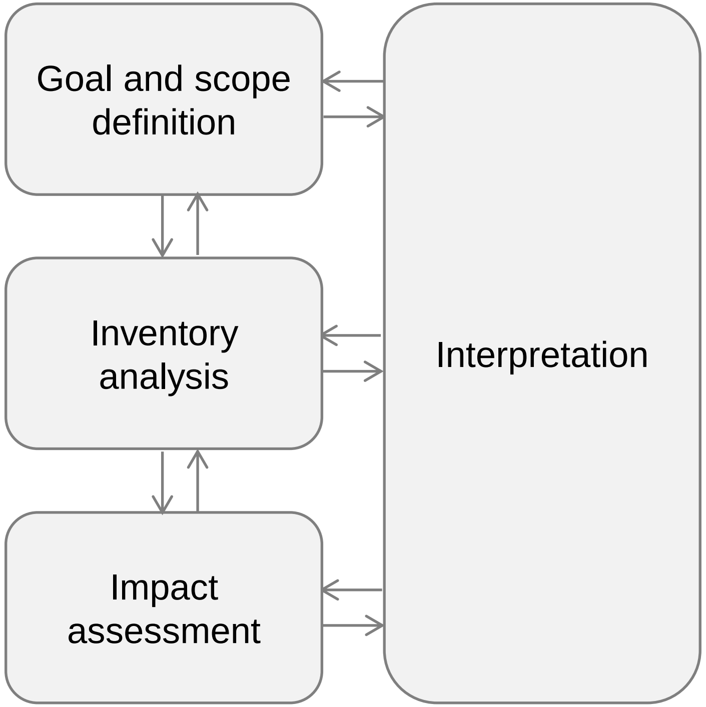
An LCA consists of four stages. First, the goal and scope of the study are defined. The system boundaries must be clearly stated, since they have a direct impact on the result of the study.

The inventory analysis is where data regarding all processes inside the system boundaries are gathered.

In the impact assessment phase, the inventory results are further analyzed and the different emissions (e.g. CO_2, SO_2, NO_x etc.) are sorted into different categories depending on what environmental impact they contribute to. For example: global warming, acidification and eutrophication.

The last stage of an LCA is the interpretation where the studied system are evaluated.

LCA is an iterative process where e.g. interpretation of the results might lead to a need to revisit goal and scope definition, inventory analysis or impact assessment, in order to create a final assessment that in the best way addresses the question that one wants to answer.



ISO 14040/-44 (2006)

Framework for this study

- Since the focus for this study is development of criteria for climate impact from a product, SS-EN ISO 14067 (2018) has been used as framework.
- SS-EN ISO 14067
  - is based on standards for life cycle assessment SS-EN ISO 14040 (2006) och SS-EN ISO 14044 (2006);
  - defines the carbon footprint of a product as the sum of GHG emissions and GHG removals in a product system, expressed as CO_2 equivalents;
  - stipulates the use of product category rules for the studied product (however, no product category rules for candles have been found);
  - refers to other standards in case the carbon footprint (i.e. kg CO_2eq per functional unit) is to be communicated to the market.
- In addition to SS-EN ISO 14067 (2018), the net climate impact per life cycle stage has been calculated and is reported below.

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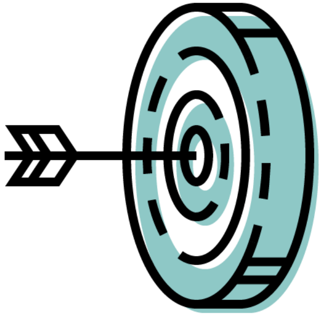
Goal and Scope

Goal



The Nordic Swan Ecolabel wants to examine the possibilities to make the reduced climate impact from Nordic Swan Ecolabelled products visible using candles as case. Criteria in focus are the *requirement O2*, stating that the amount of renewable raw material in the candle must exceed 90 % of the total weight, and the *requirement O3*, stating that vegetable raw materials from palm and soy oil must not be used.

The goal of the study is to calculate and compare the climate impact from candles produced from two different raw materials:

- Nordic Swan Ecolabelled candle from 90 % stearin (biogenic origin: animal fat), 10% paraffin (fossil raw material)
- Conventional candle from paraffin (fossil raw material)

Target group

The target group are consumers of candles.

Photo: Nathan Dumalo on Unsplash

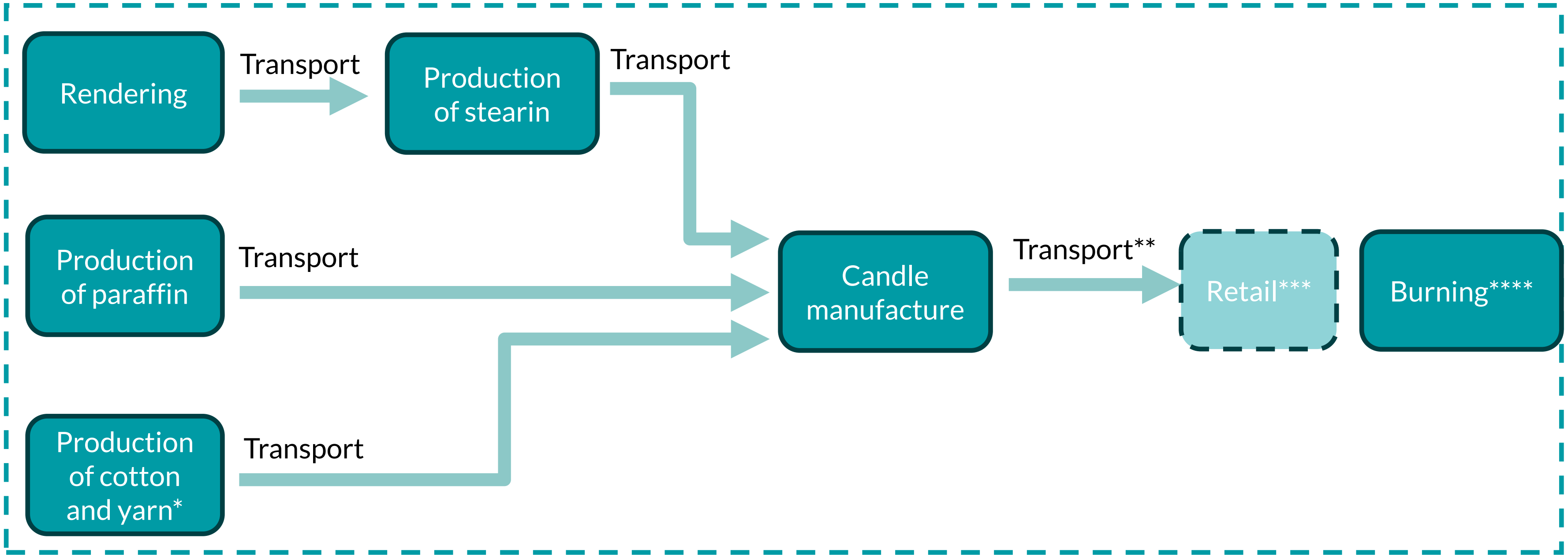
Functional Units

- 1 kg candle
- 1 MJ candle

Reference flows: 1 kg and 1 MJ of a white crown candle produced and used within the Nordic countries.

The assumed candle has a height of 20 cm, a diameter of 2,2 cm, and its cotton wick has a diameter of 1,5 mm and a length of 21 cm.

System boundaries



* Processing of cotton yarn to produce the wick is excluded.
** Storing in distribution centers is excluded.
***Storing in retail is excluded.
**** Combustion of the wick is excluded.

Assumptions

- Paraffin production and rendering of animal fat take place in several regions in Europe. The goods are transported to Karlshamn.
- Production of stearin from rendered fat takes place in Karlshamn, Sweden
- Production of paraffin takes place in Spain (Madrid) where a larger producer, communicating environmental performance using EPDs, is located and therefore could be a suitable supplier of paraffin to candle manufacturing.
- Candles of both types have identical cotton wicks.
- Manufacture of both candles takes place in southern part of Sweden (to limit the influence of transport distances on the results and since the Nordic Swan criteria currently do not include transportation)
- There is no difference between the manufacturing of the two types of candles (e.g. the energy use per kg candle is the same).
- Retail is situated in Stockholm.
- The entire candle is burned.

Delimitations

The following steps in the life cycle are identical for both types of candles and are considered to have minor contributions to the GHG emissions. They have therefore been excluded:

- Processing of cotton yarn to produce the wick
- Storing of candles (distribution centers, retail)
- Transport from retail to customer
- Combustion of the wick.

Methodology and data

- Single issue LCA (i.e. only one impact category, namely climate impact) based on SS-EN ISO14067 (2018)
- Attributional LCA approach (i.e. average, not marginal, input data are used)
- Allocation based on economic values
- Environmental impact assessment method: Climate change, EF 3.0 in SimaPro 9.5.0.0 (GWP 100, based on IPCC, 2013)
- The data in the study represents candles manufactured in Sweden and consumed in Stockholm.
- Input data and database data not older than five years.

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Life Cycle Inventory Analysis

The studied candles

Nordic Swan Ecolabelled candle (1 kg):

- 892 g stearin from animal fat
- 99 g paraffin
- 9 g cotton wick

Conventional candle (1 kg)

- 991 g paraffin
- 9 g cotton wick

Energy content based on LHV (Lower Heating Value)

Stearin: 40,03 MJ/kg (based on NIST, 2023)

Paraffin wax: 44,08 MJ/kg (Furlong et al, 2023)

Paraffin

- Production in Spain and transport to Sweden. (Although currently no production of paraffin candles takes place in Sweden, this assumption is made to limit the influence of transport distances on the results since the Nordic Swan criteria currently do not include transportation).
- Transport distance Madrid to Southern part of Sweden: 3000 km
- Based on data from the process Paraffin, Ecoinvent 3.8, see dataset in reference list.
- Transport assumed to be a truck EUR 6, Ecoinvent 3.8, see dataset in reference list.

Stearin

- Rendering of animal fat takes place in Spain (Madrid) based on data GFLI 2.0 database and the dataset ”Mixed fat”, from mixed species dry rendering, at processing/RER Economic S” (GFLI, 2023)
- Production of stearin from rendered fat takes place in Karlshamn, Sweden. We use data from the factory in Karlshamn where also a transport of animal fat from a representative mix of regions is included. (Nilsson and Shanmugam, 2021).
- Emissions at stearin production in Karlshamn are based on the information on energy use in Nilsson and Shanmugam (2021). The renewable energy used (from bio-oil and wood pellets) is approximated to wooden fuels with emission factors from SMED (2022).
- Transport by truck from Karlshamn to candle manufacturing in southern part of Sweden, 200 km.

Cotton wick

- Production in India and transport to Sweden.
- Cultivation, yinning and spinning of cotton from Ecoinvent 3.8, see datasets in reference list.
- Truck in India (EUR3) 650 km, Ecoinvent 3.8, see dataset in reference list
- Shipping from India to Sweden 23 000 km, Ecoinvent 3.8, see dataset in reference list
- Truck in Sweden (EUR6) from harbor in Karlshamn to southern part of Sweden 200 km, Ecoinvent 3.8, see dataset in reference list

Candle manufacturing

The same processes are assumed for both candles and are based on the energy use at a modern Swedish candle production (Delsbo Candle, 2021). No waste of stearin is accounted for since it is possible to recirculate all stearin without coloring. (Delsbo Candle, 2021).

	Energy use (kWh/ kg candle)	Emission factor g fossil CO_2-eq/kWh	Emission factor g biogenic CO_2-eq/kWh
Electricity	790	7,67 (AIB, 2022)	0
Fuel oil	62	288 (Naturvårdsverket, 2022)	0
Combustion of stearin	150	0	19,5 (based on NIST, 2023)

Distribution

Transport by truck from south of Sweden to Stockholm, 340 km.

Emission data for the truck (EUR 6) from Ecoinvent 3.8

Candle burning

- Combustion of stearin emits 70,3 g CO_2-eq/MJ (based on NIST, 2023). Stearin has biogenic origin and generates biogenic CO_2 emissions during combustion.
- Combustion of paraffin emits 73,3 g CO_2-eq /MJ (European Commission 2023). Paraffin is of fossil origin and generates fossil CO_2 emissions during combustion.

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Results and interpretation

Results, kg CO_2-eq/kg candle

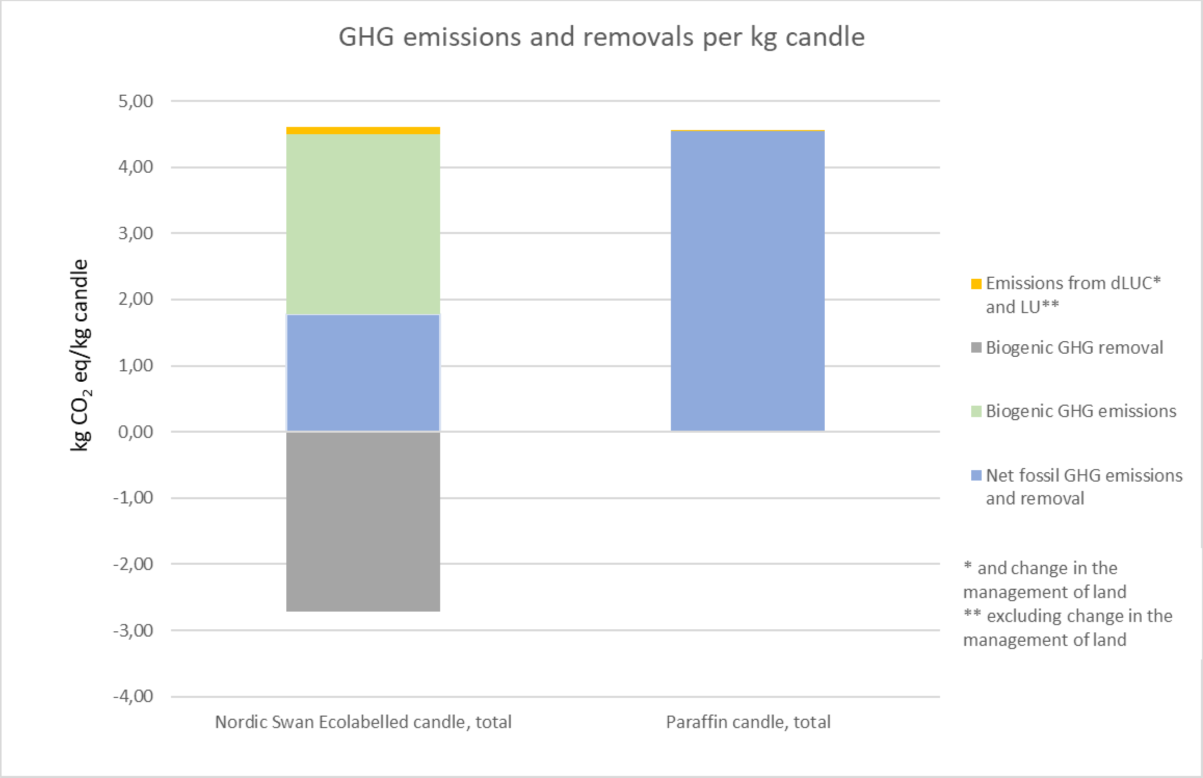
Unit: kg CO_2 eq/kg candle	Stearin production	Paraffin production	Wick production	Candle manufacturing	Distribution	Stearin, combustion	Paraffin, combustion	Total
Nordic Swan Ecolabelled candle, total	1,24	0,11	0,13	0,02	0,06	0,00	0,32	1,88
Climate change - Fossil	1,15	0,11	0,12	0,02	0,06		0,32	1,78
Climate change - Biogenic	0,21	0,00	0,00	0,00	0,00	2,51	0,00	2,72
Climate change- Biogenic uptake	-0,21	0,00	0,00	0,00	0,00	-2,51	0,00	-2,72
Climate change - Land use and LU change	0,09	0,00	0,01	0,00	0,00		0,00	0,10
Paraffin candle, total		1,14	0,13	0,03	0,06		3,20	4,55
Climate change - Fossil		1,14	0,12	0,03	0,06		3,20	4,54
Climate change - Biogenic		0,00	0,00	0,00	0,00		0,00	0,00
Climate change - Biogenic uptake			0,00	0,00	0,00		0,00	0,00
Climate change - Land use and LU change		0,00	0,01		0,00		0,00	0,01

Results, kg CO_2-eq/MJ candle

Unit: kg CO_2 eq/MJ Candle	Stearin production	Paraffin production	Wick production	Candle manufacturing	Distribution	Stearin, combustion	Parrafin, combustion	Total
Nordic Swan Ecolabelled candle, total	0,031	0,003	0,003	0,001	0,001	0,000	0,008	0,047
Climate change - Fossil	0,028	0,003	0,003	0,001	0,001	0,000	0,008	0,044
Climate change - Biogenic	0,005	0,000	0,000	0,000	0,000	0,062	0,000	0,067
Climate change- Biogenic uptake	-0,005	0,000	0,000	0,000	0,000	-0,062	0,000	-0,067
Climate change - Land use and LU change	0,002	0,000	0,000	0,000	0,000	0,000	0,000	0,002
Paraffin candle, total	0,000	0,026	0,003	0,001	0,001	0,000	0,073	0,103
Climate change - Fossil		0,026	0,003	0,001	0,001	0,000	0,073	0,103
Climate change - Biogenic		0,000	0,000	0,000	0,000	0,000	0,000	0,000
Climate change- Biogenic uptake		0,000	0,000	0,000	0,000	0,000	0,000	0,000
Climate change - Land use and LU change		0,000	0,000	0,000	0,000	0,000	0,000	0,000

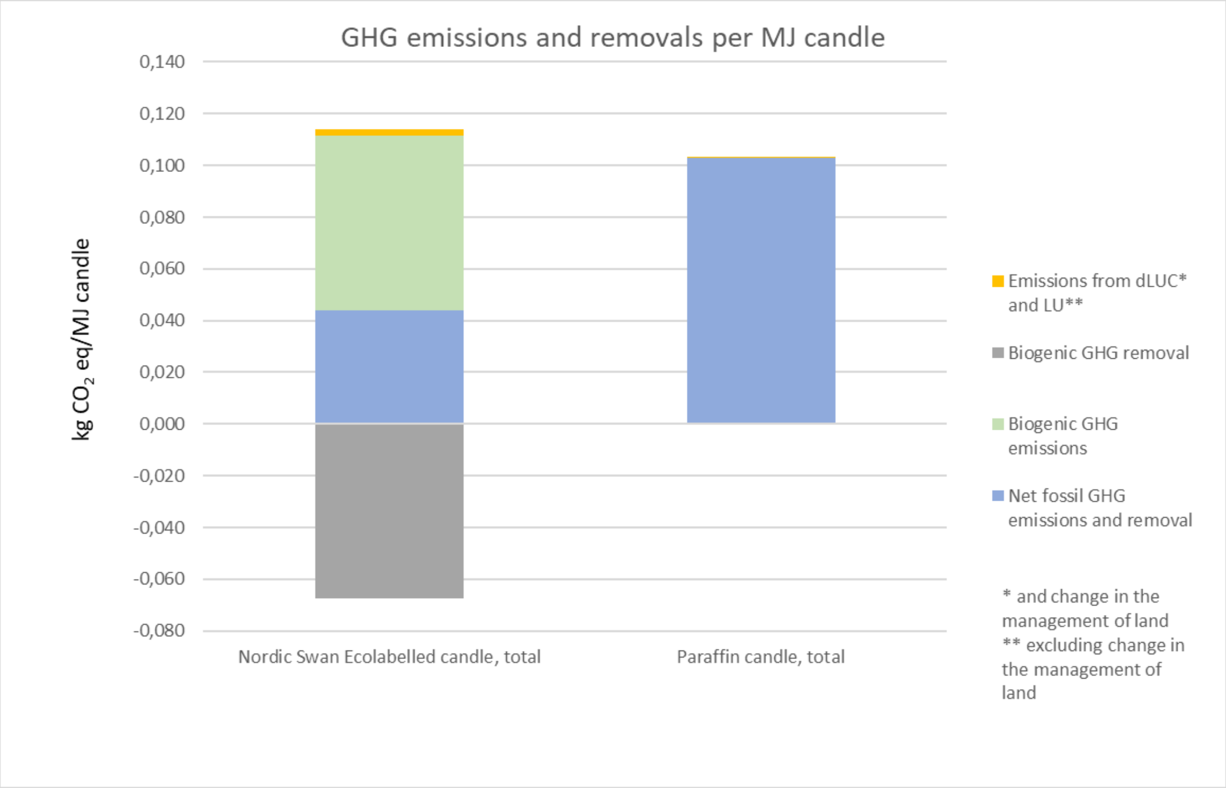
GHG emissions and removals per kg candle

- Before reporting the net climate impact in the next slides, this diagram illustrates the results per kg according to ISO14067 (2018), which stipulates that all GHG emissions and removals should be reported separately.
- The GHG emissions and removals from Nordic Swan Ecolabelled candle consist of equal amounts of biogenic emissions and removals, less fossil emissions and minor contributions from land use and land use change (economic allocation in rendering of animal fat for stearin production).
- The GHG emissions from the conventional candle consist of almost exclusively fossil emissions. There are no removals.



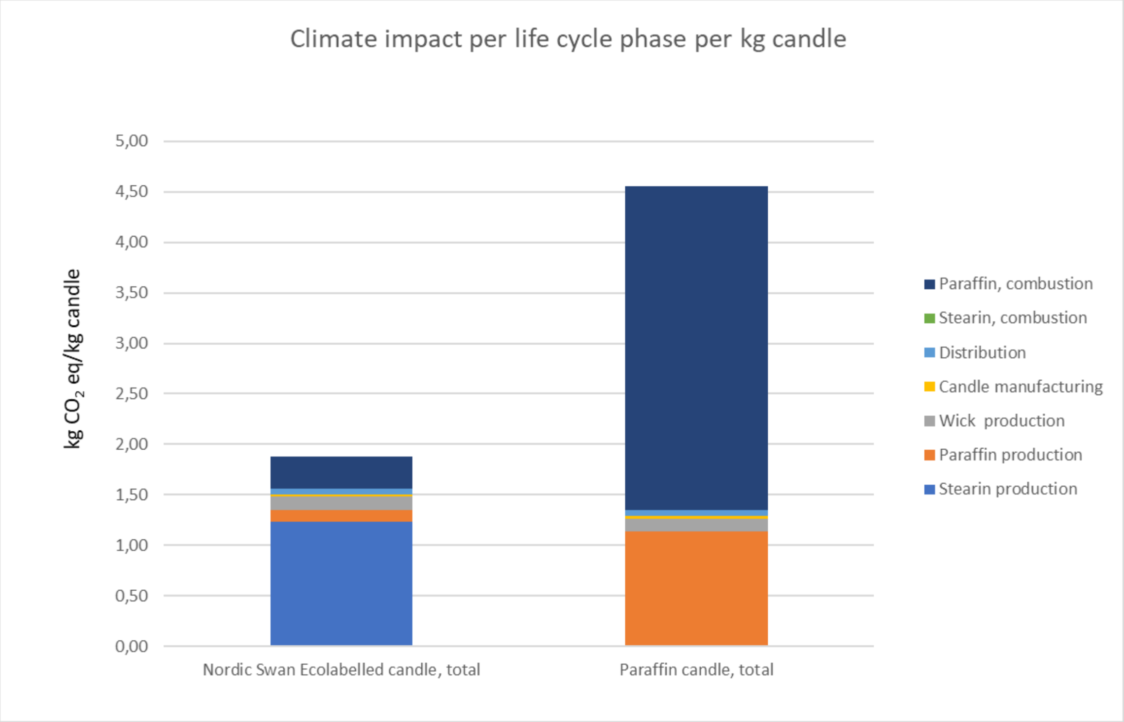
GHG emissions and removals per MJ candle

- The same comments as for the previous diagram are valid for this, where the GHG emissions and removals are reported per MJ candle. The diagrams differ only in values.



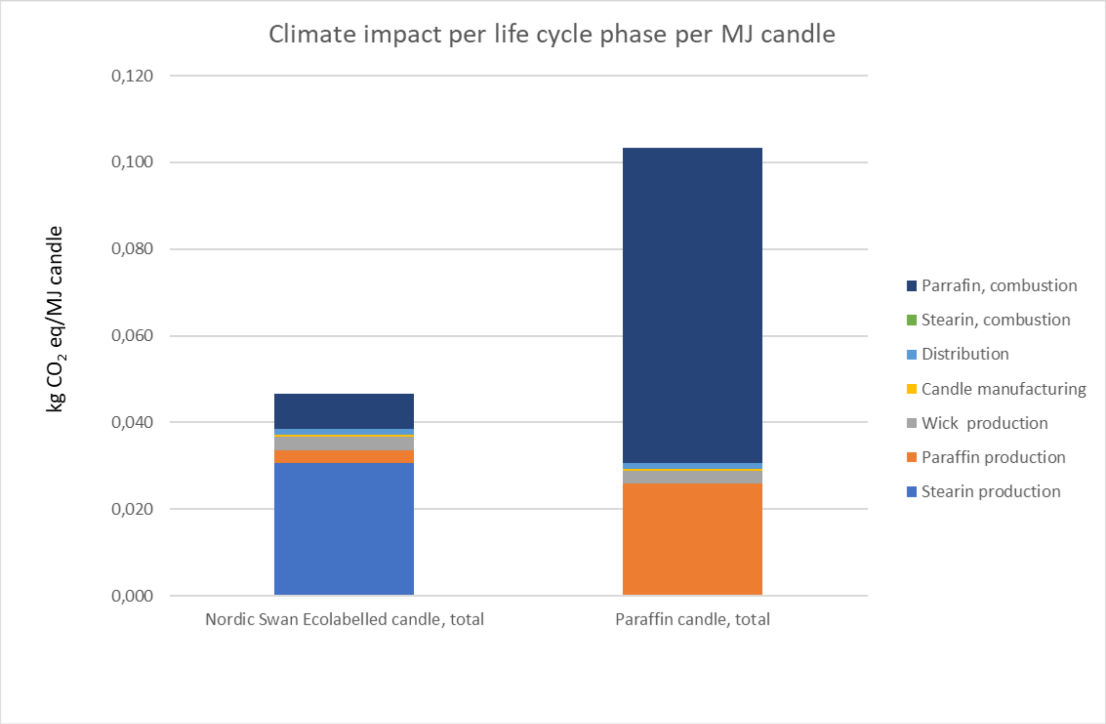
Climate impact per lifecycle phase, 1 kg candle

- Per kg candle the climate impact from the Nordic Swan Ecolabelled candle is 59 % less than the climate impact from the paraffin candle.
- The stearin production accounts for 66 % of the total climate impact of the Nordic Swan ecolabelled candle.
- The combustion accounts for 70 % of the total climate impact of the paraffin candle. For the Nordic Swan ecolabelled candles the combustion accounts for 17 %.



Climate impact, per lifecycle phase, 1 MJ candle

- Per MJ candle, the climate impact from the Nordic Swan Ecolabelled candle is 55 % less than the emissions from the paraffin candle.



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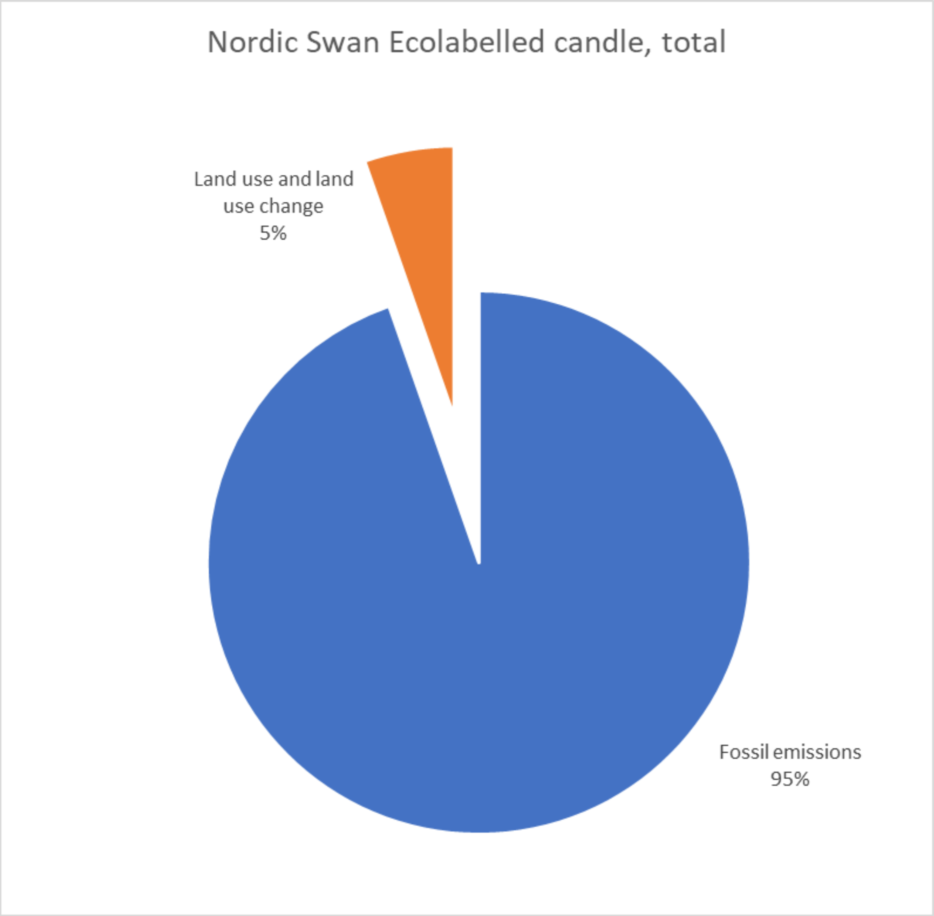
Impact from land use and land use change

- 5 % of the total climate impact of Nordic Swan Ecolabelled candles is connected to land use and land use change, most of which is due to economic allocation in rendering of animal fat for stearin production.
- For paraffin candle, the impact from land use is negligible.



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Discussion

Discussion 1(3)

- Initially, burning time was chosen as the functional unit. However, no unambigous and coherent data was found for burning times for stearin and paraffin. Therefore, two functional units have been used: energy content (MJ) and weight (kg).
- In contrast to stearin candle production, there is currently no production of paraffin candles in Sweden. To limit the influence of transport distances on the results, it was assumed that both candles were produced in Sweden.
- If another production country were to be used for the calculations, for example Poland, with a more carbon intense electricity mix, the impact on the candle manufacturing phase would increase significantly. Assuming the same amounts of energy use but replacing the Swedish electricity mix with Polish, the emissions from manufacturing would increase from 0,03 to 0,6 kg CO_2eq/kg candle, and the total climate impact for paraffin candles would increase by 13%.

Discussion 2(3)

- The data represent production and consumption in Sweden. Distribution from production to retail represents 1 – 3 % of the overall climate impact. The conclusions below would most likely be similar for consumption in the other Nordic countries, but the distribution would have a larger impact.
- In the context of LCA (Life Cycle Assessment) and in policy practices, the convention is to calculate the relative potential climate impact of gases over a one-hundred-year period. In other words, factors such as GWP100 (Global Warming Potential, 100 years) are used to indicate the impact of greenhouse gases within that timeframe. CO_2 has a GWP (Global Warming Potential) of 1 regardless of the time period since it serves as the reference. It is highly likely that there is mostly CO_2 in the studied systems, but it is uncertain how the smaller amounts of other greenhouse gases like methane and nitrous oxide would influence the results in the shorter perspective.

Discussion 3(3)

- Biogenic carbon is, in a life cycle perspective, considered to give zero climate impact. However, ISO14067 requires explicit accounting for both emissions and removals of all carbon. Hence, biogenic carbon dioxide has a negative emission factor for its uptake in biomass and a positive emission factor for its oxidation of biomass i.e. combustion of a stearin in a candle.
- Although stearin has its origin in animal husbandry, the impact from land use and land use change to the overall climate impact from the Nordic Swan Ecolabelled candle is limited, since economic allocation in rendering has been used.

NORDIC SWAN ECOLABELLED CANDLES

Conclusions

The criteria O2 contributes to lower climate impact

Both considering weight and energy content, the climate impact is lower (approximately 55-60 %) for the Nordic Swan Ecolabelled candles than for paraffin candles.

Combustion of paraffin is the hot spot for paraffin candles. The climate impact from combustion of the Nordic Swan ecolabelled candle is significantly lower, due to the mainly renewable raw material.

By setting criteria regarding a certain content of renewable raw material, the Nordic Swan Ecolabelled candles contribute to less than half of the climate impact compared to a candle made from 100 % paraffin.

Raw material extraction is an important factor

- By reducing the content of fossil raw material there is a shift in hot spot for the candles: while the paraffin candle has the highest net emissions in the combustion phase, the Nordic Swan Ecolabelled candles has the highest net emissions in the production of raw materials.
- The impact from land use is low, also when including upstream emissions from animal fat, used for the production of stearic acid.

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References

Standards

- SS-EN ISO 14067:2018. Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification, SIS, Swedish Standards Institute.
- SS-EN ISO 14040:2006. Environmental management – Life cycle assessment – Principles and framework. SIS, Swedish Standards Institute.
- SS-EN ISO 14044:2006. Environmental management – Life cycle assessment – Requirements and guidelines. SIS, Swedish Standards Institute.

Inventory data 1(2)

- AIB (2022). Association of Issuing Bodies. 2021 European Residual Mix - Results of the calculation of Residual Mixes for the calendar year 2021 (Version 1.0, 2022-05-31) https://www.aib-net.org/facts/european-residual-mix/2021
- Delsbo Candle (2021). ”Hållbarhetsrapport Delsbo Candle 2020”, 2021-01-08, https://www.delsbocandle.se/uploaded_files/hallbarhetsrapport-delsbo-candle-2020.pdf, downloaded the 10 October 2023
- EC (2023). Commission delegated regulation (EU) 2023/1185 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council.
- Ecoinvent, Allocation, cut-off by classification, ecoinvent database version 3.8 (2021), following processes are used:
  - Paraffin {RER}| production | Cut-off, U
  - Transport, freight, lorry 16-32 metric ton, euro6 {RER}| market for transport, freight, lorry 16-32 metric ton, EURO6 | Cut-off, U
  - Seed-cotton {IN-GJ}| seed-cotton production, conventional | Cut-off, S
  - Fibre, cotton {IN}| fibre production, cotton, ginning | Cut-off, U
  - Yarn, cotton {IN}| yarn production, cotton, open end spinning | Cut-off, U
  - Transport, freight, sea, container ship {GLO}| market for transport, freight, sea, container ship | Cut-off, U
  - Transport, freight, lorry 16-32 metric ton, euro3 {RoW}| market for transport, freight, lorry 16-32 metric ton, EURO3 | Cut-off, U

Inventory data 2(2)

- EFPRA (2022). “White Paper – Life Cycle Assessment of Rendered Products (GFLI methodology)”. https://efpra.eu/wp-content/uploads/2022/03/Life-Cycle-Assessment-of-Rendered-Products-GFLI.pdf, downloaded the 5 May 2023
- Furlong A., Haelssig J., Pegg M. (2023). ”Impact of candle wicks and fuels on burning rate, flame shape, and melt pool diameter”. Combustion and Flame 249 (2023) 112628
- GFLI (2023). Global Metrics for Sustainable Feed. Stearin acid production data, https://globalfeedlca.org/ downloaded the…. October 2023
- Naturvårdsverket (2022). Klimatklivet - Vägledning om beräkning av utsläppsminskning. https://www.naturvardsverket.se/4990ca/globalassets/amnen/klimat/klimatklivet/vagledning-berakna-utslappsminskning-2022-11-30.pdf, downloaded the 17 October 2023
- Nilsson K. and Shanmugam K. (2021) ”LCA of Stearin and Paraffin”. RISE report P109847. Personal communication.
- NIST (2023). NIST Chemistry WebBook, NIST Standard Reference Database Number 69, Last update to data: 2023. DOI: https://doi.org/10.18434/T4D303. Data on stearin from https://webbook.nist.gov/cgi/cbook.cgi?ID=C555431&Mask=FFFF&Units=SI, downloaded the 5 October 2023
- SMED (2022). Emissionsfaktorer och värmevärden submission 2023, Ansvarig myndighet: Naturvårdsverket, Uppdaterad 2022-12-15

Elin Einarson Lindvall

+46 1 516 57 27

+46 73 069 67 19

Elin.Einarson.Lindvall@ri.se

Katarina Lorentzon

+46 10 516 66 97

+46 70 492 27 00

Katarina.lorentzon@ri.se