LIFE CYCLE ASSESSMENT (LCA) OF A LUNGO CUP OF COFFEE MADE FROM A NESPRESSO ORIGINAL CAPSULE COMPARED WITH OTHER COFFEE SYSTEMS IN SWITZERLAND

Executive Summary

In 2018, *Nespresso* commissioned Quantis, a leading consulting firm specialized in sustainability, to perform a life cycle assessment (LCA) of a cup of lungo coffee (110 ml) made from various coffee systems, at home, in Switzerland. This study examined the life cycle of a cup of coffee from the extraction and processing of all raw materials through the end-of-life of all components, including packaging (a cradle-to-grave approach). The study assessed the impact of a lungo cup of coffee prepared using the *Nespresso* Original system in Switzerland compared with three other coffee preparation systems commonly found in the Swiss market: a moka, a drip filter and a full-automat system.

The results show that for all coffee systems, impacts are systematically dominated by the use stage – the preparation of the coffee at home – followed by the green coffee supply stage, which encompasses coffee production in the country of origin and its transportation to Switzerland.

Considering the scenarios studied for the different coffee systems, the study concluded that the *Nespresso* Original, the drip filter and the moka coffee systems all have similar impacts on climate change resulting from a similar carbon footprint. The full automat coffee system appears to have the most climate change impact as it has a higher carbon footprint.

To follow the requirements of the International Organization for Standardization (ISO) 14040/ 14044 standards for a comparative assertion and public disclosure, this comparative LCA study has been peer-reviewed by three independent experts.

1. Background and context

Over 30 years ago, *Nespresso* revolutionized coffee culture with its invention of a compact portioned coffee system for easy at-home use.

Today people are increasingly concerned with the environmental impact of portioned coffee capsules. More and more, people question the use of resources in the production process and the impacts of the capsule packaging after usage. With the evolution of the brand and product range over the last three decades, *Nespresso* has taken various steps to improve its environmental performance. Among other initiatives, *Nespresso* introduced its own recycling system in 1991 and worked to improve the energy efficiency of its machines.

To identify key focus areas to further improve its environmental performance, *Nespresso* commissioned Quantis, an international sustainability consultancy, to carry out a Life Cycle Assessment (LCA) of a lungo cup of coffee (110 ml) made and consumed in Switzerland. The study aimed to respond to two key questions:

1) What is the impact of the *Nespresso* preparation system on the environment?
2) How does it compare to other coffee preparation systems commonly used in Switzerland?

1.1. Life Cycle Assessment (LCA) – what is it?

In order to assess the impact of a product on the environment, its entire life cycle must be considered. This is because the environmental impact of a product goes beyond the use or consumption of that product. The life cycle of a product is defined by the production, distribution, use and end-of-life (usually disposal) stages. The life cycle assessment quantifies the environmental impacts related to all the raw materials used to manufacture, distribute, use and treat the product at the end of its life. The life cycle assessment considers various indicators to assess different environmental impacts such as carbon footprint, water footprint, or impacts on biodiversity.

Using the life cycle assessment methodology, it is also possible to compare different products, considering the same unit of reference for all systems compared and all life cycle stages. One product may perform worse at a stage visible to the consumer, but at another stage it may perform significantly better for the environment than comparable products, often leading to unexpected conclusions.

The present life cycle assessment conforms to the International Organization for Standardization (ISO) 14040/ 14044 standards for a comparative assertion and public disclosure and has been peer-reviewed by independent experts from EMPA, Topten International Services and the EPFL. Its results are representative of the year 2017.

It is important to note that LCA does not quantify the exact impacts of a product or service due to data availability and modelling challenges. However, LCA allows a scientifically based estimation of the environmental impacts a system might cause over its typical life cycle, by quantifying (within the current scientific limitations) the likely emissions produced and resources consumed.

2. What is the scope of the study?

This study assessed the life cycle of a lungo cup of coffee (110 ml) prepared and consumed at home, in Switzerland. The study included the extraction of all raw materials and coffee cultivation through the end-of-life of all components, including packaging. The study was done for the *Nespresso* Original coffee preparation system, as well as three other coffee systems commonly found in Switzerland: drip filter, moka and full automat. As the objective is to compare the coffee systems and not the coffee cultivation, it was decided to consider the same green coffee cultivation, delivery and processing for all systems.

Coffee is consumed differently in every household. Some people like to drink coffee in the morning, others in the afternoon and others rather irregularly. In order to achieve comparable results, the study assumes an average drinking habit of 2 cups of lungo coffee per day at home. For all coffee systems compared in the current study, a preparation of a 110 ml lungo cup of coffee was assumed, except for the moka coffee system, for which a volume of 100 ml is considered (moka coffee makers are only available in multiples of 50 ml sizes).

The study assessed the following scenarios for four of the most commonly sold coffee systems in Switzerland:

Nespresso

Nespresso Original lungo capsule prepared with the most commonly sold *Nespresso* machine on the Swiss market: **Nespresso Inissia**

The *Nespresso* Original system uses portioned coffee to prepare espresso, ristretto or lungo coffees. The coffee ground comes in aluminium capsules that are inserted in the machine. Water under high pressure is pumped through the capsules, and the brewed coffee flows through a funnel into the coffee cup.

Full Automat

Coffee prepared using a full automat coffee system, with the full automat machine most commonly sold on the Swiss market: **Delonghi Ecam 21.117.W/B/SB Magnifica S.**
A full automat coffee system can produce various types of coffee fully automatically according to the espresso method. The machine grinds the coffee beans according to the desired grinding degree and weighs them according to the selected product. The heated water is pressed under pressure through the coffee powder.

Drip Filter

Coffee prepared using a drip filter coffee machine, with an average drip filter model with heating plate and glass container following data outlined in the **Draft PEFCR coffee average machine.**
A drip filter machine pours water into a paper filter filled with coffee grounds. The water flows through the ground coffee, dripping into a container placed under the filter. The filter prevents the coffee powder from getting into the coffee.

Moka (Italian) coffee maker

Coffee prepared using a moka coffee maker, on an electric stove: **Moka coffee maker in aluminium (200 ml)**
A moka coffee maker is used to prepare coffee on the stove-top. Water is poured into the boiler. The funnel insert is filled with coffee powder and inserted, after which the machine is screwed together. The boiling water is pressed through the coffee powder, which fills the upper container with coffee.

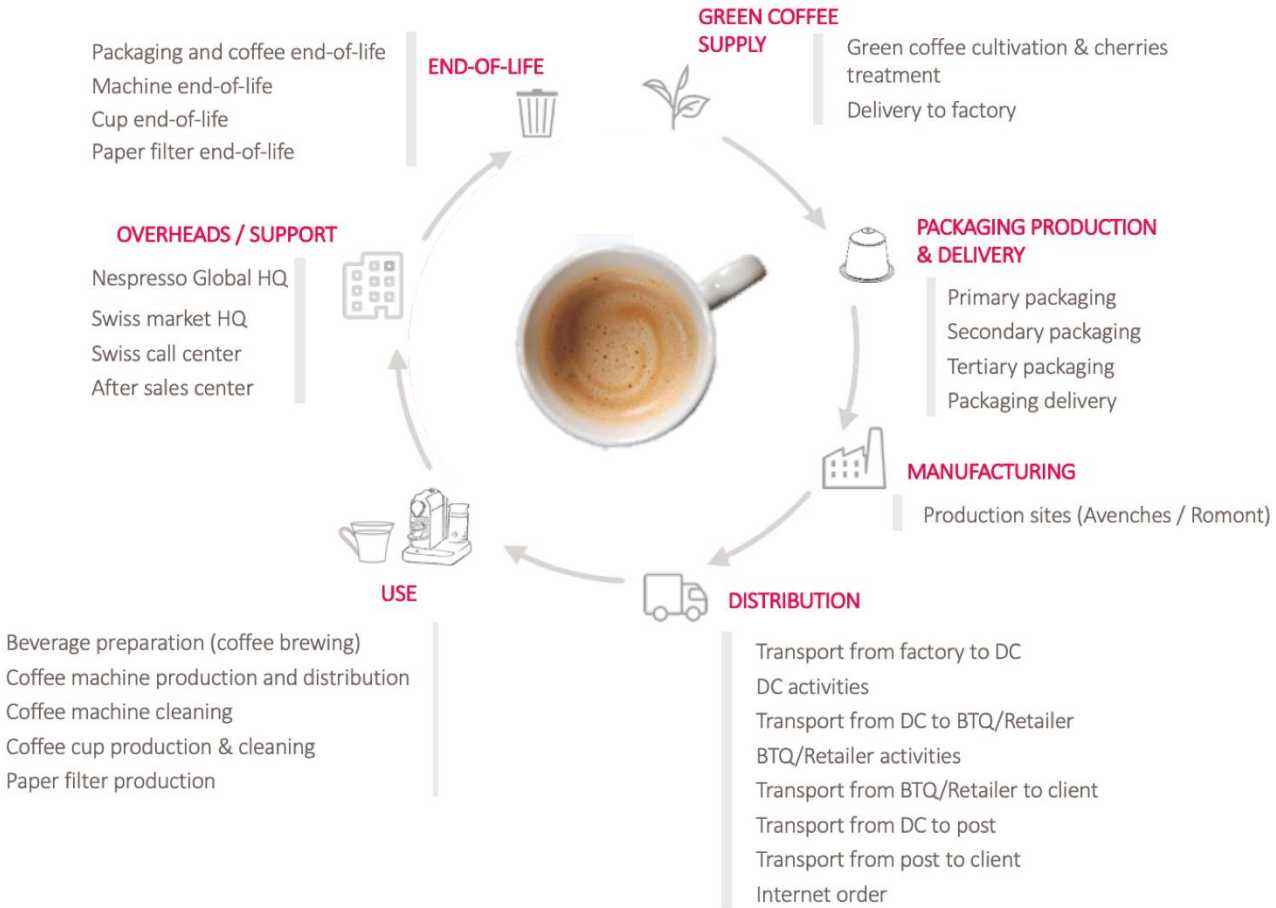
To determine the environmental impact of the *Nespresso* preparation system, fully automatic machines, moka and filter coffee, the study considers different stages of the coffee product life cycle.

- **Green coffee supply**
  The study analyzes the complete coffee cultivation, including agrochemical use, irrigation, land use change[1], energy and water consumption for coffee cherries processed into green beans and transported to Europe. The same coffee supply is considered for the four coffee systems assessed: a wide variety of coffee is available for moka, full automat and drip filter systems (that can have higher or lower impacts than the Nespresso coffee), and therefore it has been decided not to differentiate the coffee systems on the type of coffee but only on the quantity.
- **Packaging production and delivery**
  To calculate the impact of the packaging material, the environmental impact of the materials from which the coffee packaging or capsules are made is considered. This includes the primary packaging (e.g. the aluminium capsule for *Nespresso*), the secondary or outer packaging (e.g. sleeves), and the tertiary packaging used for the delivery (e.g. Europallet, or large cardboard boxes).
- **Manufacturing**
  The examination includes all steps of further coffee processing such as roasting and grinding in the

[1] Land use change includes every change in the use of a land. It can be a change from e.g., grassland to an arable crop, from an arable crop to another arable crop or to a perennial, or from a primary or secondary forest to arable or perennial crop (i.e., deforestation). Deforestation is the permanent destruction of forests in order to make the land available for other uses. This is the main contributor to the impacts from land use change. The amount of land transformed over the last 20 years for the different countries of coffee origin and from forest or grassland to perennial cropland (coffee cultivation) is based on FAOstat data and taken from the direct land use change assessment tool developed for GHG protocol by Blonk Consultants. It corresponds to statistical land use change per crop and per country and not to specific farming practices.

production sites, e.g. in Avenches for *Nespresso*. The same manufacturing process has been considered for all coffee systems. The drip filter and moka use roast and ground coffee, while Nespresso and full automat use coffee beans. It can be noted that grinding the beans is negligible in terms of energy consumption.

- **Distribution**
  Includes the transport routes from production to the point of sale or to the customer. In the case of Nespresso, the distribution can be via boutiques or supermarket, including a shopping trip of the consumer, or via postal delivery.
- **Use**
  The study examines the environmental impact of various aspects: In addition to the energy and water involved in brewing coffee, it also examines the complete production of machines with all the necessary materials, delivery, cleaning and disposal, as well as the cup production and washing.
- **Overheads/support**
  In this stage, aspects related to the backbone of the company are analyzed, for example, the *Nespresso* headquarters in Lausanne or Swiss call centres. The data for this step is known only for Nespresso but similar life cycle stages exist for the other coffee systems. Therefore, the same impacts for overheads/support per cup of coffee is considered for all coffee systems.
- **End-of-Life**
  The final stage covers the collection, sorting and recycling of packaging materials, capsules and coffee grounds. For Nespresso, the end-of-life considers 50% recycling and 50% incineration with energy recovery, reflecting the situation in Switzerland.



Environmental impact indicators
The life cycle assessment of a lungo cup of coffee studies the contribution of the life cycle stages for various environmental impacts: carbon footprint, non-renewable resources consumption, land use (i.e. how much land is needed for cultivation or for buildings to process the coffee), impacts on ecosystem quality (measuring the effects on biodiversity), human health impacts (measuring the indirect effect on human health from the whole coffee system) and finally, water consumption (throughout the whole lifecycle, not just in the use phase). These indicators have been assessed in the full study, but only the results for carbon footprint are presented in this summary for simplification reasons. The conclusions for the other indicators were in-line with the conclusions for carbon footprint.

3. Key results

3.1 The environmental performance of the *Nespresso* Original system

One 110 ml cup of *Nespresso* coffee emits about 100 g CO_2-eq. The carbon footprint of a *Nespresso* lungo is dominated by the use stage (45%) and green coffee supply (35%). Packaging contributes 14% of the greenhouse gas emissions of the *Nespresso* preparation system. Overheads & support rank fourth (7%), followed by manufacturing (3%) and distribution (2%). End-of-life treatment – namely the recycling or incineration of the capsules and other packaging items – improves the environmental performance with a negative balance (-5%), reducing the total final carbon footprint.

3.1.1 Use stage

The largest contributor to the carbon footprint of the use stage of a lungo cup of *Nespresso* coffee is the cup production and washing (61%). This is mostly due to the dishwasher electricity requirements to clean the cup after each use and the allocated part of the dishwasher manufacturing and end-of-life. The second highest impact on climate change in the use stage for the *Nespresso* coffee system is the coffee brewing (21%). If a consumer's energy supply at home is based on renewable instead of non-renewable electricity, this could lead to a 7 g CO_2-eq (7%) decrease in impact per cup in the coffee brewing stage. The machine production, distribution and cleaning of the machine is the least impacting factor (18%), since Inissia is relatively light (2.4 kg) and therefore consumes few materials, transport and energy.

3.1.2 Green coffee supply

The *Nespresso* coffee capsule contains 6.1 g of ground coffee to make a lungo (110 ml) cup of coffee. Considering the coffee grounds in one lungo *Nespresso* capsule, the green coffee supply accounts for 35% of the total carbon footprint of a cup of *Nespresso* coffee. Fertilizer use and land use change[1] are the largest contributors (about 40% each) of greenhouse gas emissions to the green coffee supply. The remaining emissions are mostly related to the combustion of fossil fuels for field irrigation, the treatment and delivery of coffee cherries from the farms to the processing sites, and the processing itself. The delivery to the factories in Switzerland represents 7% of the carbon footprint for this stage.

3.1.3 Packaging and delivery

The aluminium (1 g) of the primary packaging for a *Nespresso* capsule leads to 11% of the impacts on climate change. Recycling aluminium and providing the market with secondary aluminium enables *Nespresso* to contribute to reducing the need to produce more primary aluminium, leading to a net greenhouse gas emissions benefit (included at the end-of-life stage). While the impacts associated to the secondary and tertiary packaging appear similar for all coffee systems (about 2-3 g CO_2-eq), the difference between the *Nespresso* coffee system and the other systems is largely driven by the primary packaging.

The current study notes that if the aluminium used is produced with 100% renewable electricity, the environmental impact of the packaging stage can be further improved, lowering the greenhouse gas emissions of the system by 4 g CO_2-eq (4%).

3.1.4 Overheads / Support

7% of the total greenhouse gas emissions come from the overheads and support stage. The overheads for Nespresso include the activities related to the global headquarters administrative center, the Swiss market head office, the Swiss after sales centers and the Swiss call center. For each of these elements, the system includes the building, electricity, natural gas, paper and water consumption, the IT equipment, the employees commuting and the business travels. For the global headquarters, the impacts related to various services (mostly advertising) are assessed through their economic value and a database linking costs to environmental impacts. These services are responsible for the major part of the carbon footprint related to overheads/support (40%) while the business travels of the market head office and the energy consumed in different buildings correspond to the other hotspots.

3.1.5 Manufacturing

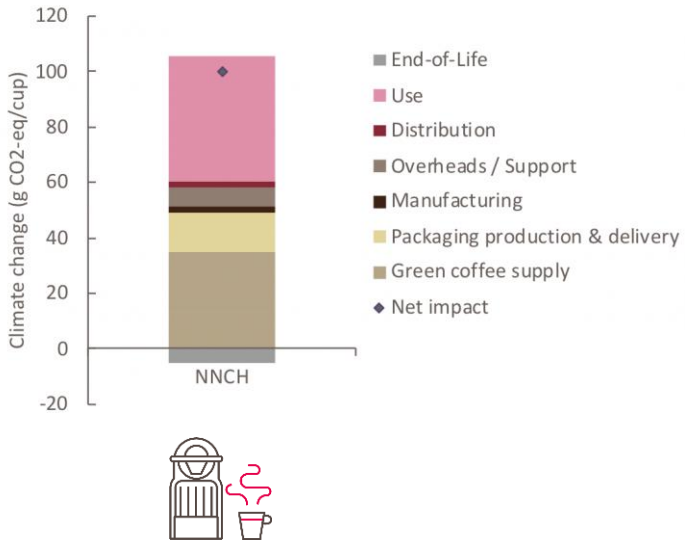
This life cycle stage causes 3% of the carbon footprint of a cup of 110 ml *Nespresso* and includes the energy, water, gases, building, machinery that are needed for the processing of green coffee into roast and ground coffee. The wastes generated and their treatment were also considered. The data correspond to the production center of Avenches (all lungo Original capsules are produced in the Avenches production center, one of the three manufacturing sites of Nespresso). The carbon footprint score for this life cycle stage is mostly due to the natural gas consumption, the nitrogen use (to prevent oxidation in the production line) and the packaging losses (packaging scraps need to be treated but require an additional material input to compensate the losses).

3.1.5 Distribution

2% of the total greenhouse emissions are created in the distribution stage. For the Nespresso capsules, the distribution can be done either via boutiques or via postal delivery. For the distribution via boutiques, the transport from the manufacturing site (Avenches) to the boutiques was considered, as well as the impacts of boutique themselves (energy, water and paper consumption, IT equipment, employee-related activities such as business travels and commuting) and finally the consumer shopping trip. The postal distribution includes the transport from the manufacturing site to the “arrival post”, then the postal delivery from the post office to the consumers’ home. The electric consumption related to the internet use for the order is also included. Most of the carbon footprint for this stage is due to boutique activities (energy consumption and commuting by car) and to transport by truck.

3.1.6 End-of-life

The end-of-life of the *Nespresso* coffee system (assumed 50% recycled and 50% incinerated with energy recovery) using aluminium as primary packaging material leads to a greenhouse gas emission benefit (-2%). A higher recycling rate would improve the environmental performance. The largest contributor to the total benefit of -5 g CO_2-eq comes from the coffee grounds which are sent to a biogas production plant when the capsules are recycled.



The carbon footprint of a Nespresso lungo (110 ml) cup of coffee

3.2 The environmental performance of the four examined coffee systems

For all coffee systems and all indicators, impacts are systematically dominated by the use stage (42% to 52%) and the green coffee supply (35% to 46%). They have a greater impact on the environmental balance than packaging, which ranks third (3% to 14%). These three stages represent around 90% of the total greenhouse gas emissions of a 110 ml lungo cup of coffee made and consumed in Switzerland. The remaining 10% consist of the end-of-life stage (which significantly varies depending on the considered coffee system), the manufacturing and overheads/support stages as well as distribution, which has the lowest impact overall.

As the same manufacturing impacts per kg of green coffee are considered for all coffee systems, it means they all use renewable electricity. This benefits the competitive systems as their manufacturing does not necessarily use renewable electricity in reality, but it is a safer approach in the context of this study that compares the environmental impacts of Nespresso with other coffee systems.

Based on the studied coffee system baseline carbon footprint, it can be mentioned that *Nespresso*, drip filter and moka coffee systems have similar impacts. The full automat coffee system has the highest carbon footprint of all the systems.

3.2.1 The use stage

The use stage has the greatest environmental impact for all examined coffee preparation systems. The cup production and washing has the largest contribution to the use stage carbon footprint (38-62%), except for the full automat coffee system where impacts are dominated by the machine production due to its heavy weight (40%). Impact caused during brewing typically represents about 17-33%. For drip filter, the paper filter production and distribution were also included and represent 8% of the drip filter use stage carbon footprint. The impact of the water filter production and distribution for the full automat system and the rubber seal production and distribution of the moka coffee system are low.

The use stage of *Nespresso* and moka coffee systems lead to similar greenhouse gas emissions, while the use stages of drip filter and full automat coffee systems are characterized by higher greenhouse gas emissions. Looking specifically at the coffee brewing related aspects, the moka and drip filter coffee systems are more impacting due to their larger energy consumption when they are heated. Varying consumer behavior has further implications on this: for example, brewing with the moka coffee system has an even greater impact if

the consumer uses an oversized heating plate, leading to higher energy consumption than necessary. With the drip filter coffee system, energy can be wasted if the consumer uses a non-insulated drip filter pot or keeps it on the warm mode. *Nespresso* machines have an automatic switch-off/standby function, which helps to optimize the energy consumption independent of consumer behavior.

3.2.2 Green coffee supply

The cultivation of coffee has the second greatest influence on the greenhouse gas emissions. All coffee systems were examined using the same green coffee supply and deforestation model for better comparability across systems despite a lack of comparative data from other companies (full automat, drip filter and moka can use a wide variety of coffee, in terms of origin, farming practices, and cherries treatment). The differences observed among the systems are related to the amount of coffee used per cup only. The contributors to this life cycle stage that are described in section 3.1.2 above are applicable for all coffee system as the same green coffee is used for all.

3.2.3 Packaging and delivery

The coffee pouches (laminate of plastic and aluminium) used for the other systems are assumed to be the same for all but the amount of coffee per cup varies. The impact of the *Nespresso* coffee system in the packaging stage is higher than for the other three coffee systems (3.5 to 5 times higher). This is mainly due to the amount of aluminium that is needed to produce the capsules, i.e. the primary packaging.

3.2.4 Distribution

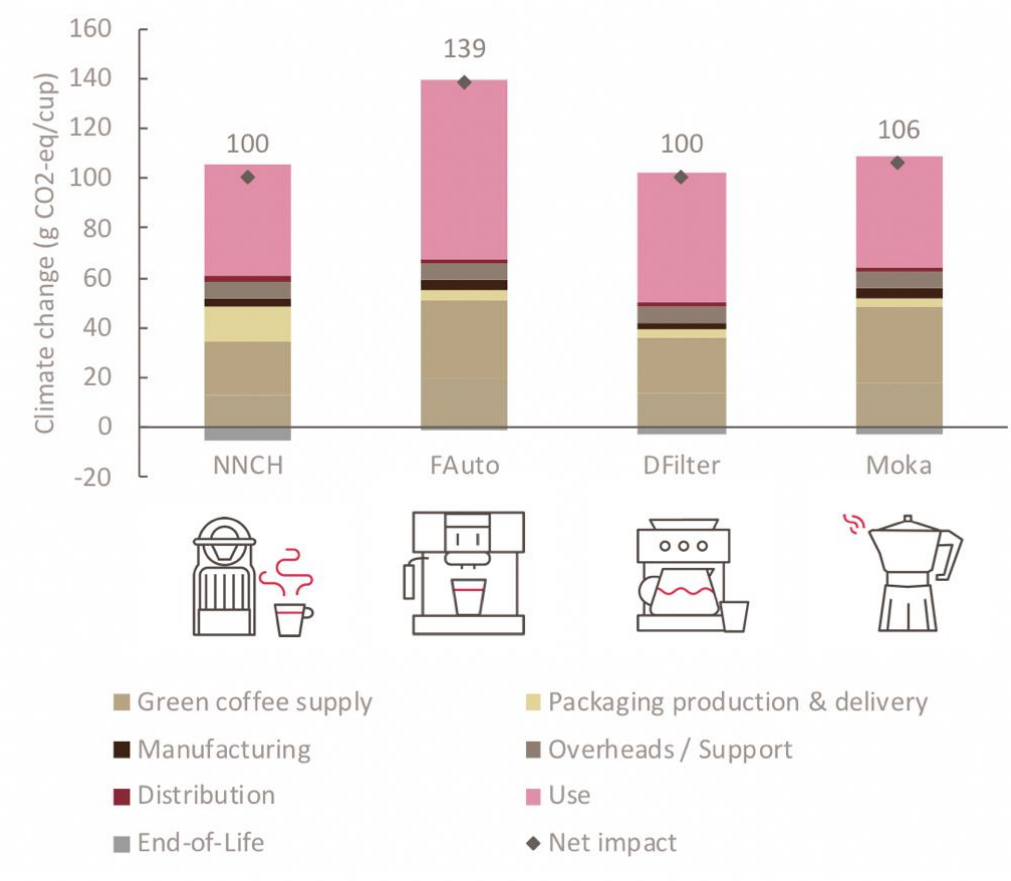
This stage emits about 2 g CO_2-eq for all coffee systems and is driven at 70% by retail and boutique activities. The remaining distribution emissions are almost entirely driven by the transport activities – postal delivery or transport to the retail and boutiques.

3.2.5 Manufacturing and Overheads / Support

These stages together contribute less than 10% of the total greenhouse gas emissions, and they were modelled using the same process for all coffee systems. For manufacturing, the same process is considered for all due to a lack of data for the full automat, drip filter and moka. Given the wide variety of coffee that can be used for these 3 systems, the manufacturing could vary. However, as Nespresso uses 100% renewable electricity for its manufacturing, it was seen as a conservative assumption to consider the same for all systems. The manufacturing impacts are calculated per kg of coffee and therefore the systems have a higher or lower manufacturing impact depending on the amount of coffee used per serving. Regarding the overheads/support, no evidence could be found on how a specific coffee system could perform better than another and therefore no differentiation could be made based on this stage.

3.2.6 End-of-life

The end-of-life of the different coffee systems do all lead to net greenhouse gas emission benefits ranging from -5 g CO_2-eq (*Nespresso*) to -1 g CO_2-eq (Full automat). This general greenhouse gas emission benefit is mostly explained by the end-of-life of coffee grounds which leads to negative emissions for all coffee systems (the different treatments include; incineration with energy recovery, composting, or biogas generation). The machine end-of-life represents less than 3% of the machine production impacts.



Comparison of coffee systems' carbon footprint (Swiss market)

3.3. Comparing the Nespresso preparation system with other systems

In this section, the *Nespresso* system is compared individually with the other three coffee systems tested, focusing on significant differences or similarities.

3.3.1 Comparing the *Nespresso* system with the drip filter coffee system

- The drip filter coffee system and the *Nespresso* coffee system have similar environmental impacts (for the 6 environmental indicators assessed in the study).
- The use stage impact of the drip filter is slightly higher than the *Nespresso* coffee system due to the one-way filter paper and the higher energy consumption during coffee brewing.
- The green coffee supply stage for the drip filter coffee system is slightly more impacting because the assumed amount of coffee for 110 ml is 6.4 g compared to 6.1 g of a *Nespresso* capsule.
- The packaging stage of the drip filter coffee system is less impacting than the *Nespresso* coffee system.
- The drip filter coffee system is subject to high consumer-related variations. When used in a responsible manner, the drip filter coffee system can have a better performance than the *Nespresso* coffee system. However, an inefficient use during coffee preparation – for example if consumers waste prepared coffee, use an extra amount of R&G coffee, or use an un-insulated drip filter pot – can cause the drip filter coffee system to have a higher impact.

3.3.2 Comparing *Nespresso* with the moka coffee system

- The moka and the *Nespresso* coffee systems have similar environmental impacts.

- The use stage impact of the moka coffee system is similar to *Nespresso*. The higher energy consumption of the moka coffee system during coffee brewing is evened out with a less impacting machine production, distribution and cleaning.
- The green coffee supply stage for the moka coffee system is more impacting because the assumed amount of coffee is 8.5 g compared to 6.1 g of a *Nespresso* capsule. It has to be kept in mind that the cup of coffee made from the moka coffee system is slightly smaller than the one prepared by the other systems (100 ml instead of 110 ml) due to the inherent size of the moka coffee maker.
- The packaging stage of the moka coffee system is less impacting than the *Nespresso* system.
- The moka coffee system is subject to high consumer-related variation. While for a responsible use, the moka coffee system can lead to better performances than the *Nespresso* coffee system, an inefficient use by the consumer during preparation – for example superfluous coffee poured away or an oversized heating plate – can make the moka coffee system more impacting.

3.3.3 Comparing *Nespresso* with the full automat coffee system

- The full automat coffee system appears to be the coffee system with the highest environmental impacts.
- It has a 30% higher carbon footprint than the *Nespresso* coffee system.
- The most significant impacts associated with the full automat coffee system are driven by 2 parameters: the large amount of coffee used per cup – with 9 g per cup, the full automat uses a considerably higher amount of coffee than the Nespresso preparation system (6.1 g) - and the heavier machine (9.1 kg vs. 2.4 kg) which contributes heavily to the impacts associated with the machine production and distribution. The two machines are assumed to have the same lifetime and usage intensity (i.e., 2 cups/day, which is the average home consumption in Switzerland). A more intensive use of the machine would reduce the contribution of the machine production to the overall carbon footprint and the difference between the two scenarios.
- The packaging stage is less impacting for the full automat coffee system than the *Nespresso* coffee system.
- Even when changing some of the parameters to best- and worst-case parameters for both systems (e.g. 0% recycling for the *Nespresso* system, a lighter machine, or 20% less coffee for full automat system etc.), the worst case of *Nespresso* still has less impact than the best case of the full automat coffee preparation system.

4. Conclusion

The holistic view on the life cycle of the four different coffee preparation systems shows that drinking a 110 ml lungo cup of coffee made from a *Nespresso* coffee system in Switzerland has a similar environmental impact as the same cup of coffee made with a drip filter coffee system or a moka coffee system. On the other hand, preparing a cup of coffee with a full automat preparation system has a higher environmental impact since the machines are heavier and a greater amount of coffee is used.

A large part of the impact on the environment is rooted in the coffee preparation at home (cup production and washing, brewing of the coffee, machine production, distribution and washing), and cultivation of the green coffee. The environmental impact of coffee consumption increases significantly when consumers do not dose exactly, throw out left-over coffee, or use machines irresponsibly, especially when it comes to energy consumption. Unportioned coffee system performances are much more dependent on consumer behavior than portioned coffee systems. In other words, a more responsible consumer could have a lower impact using a drip filter or a moka than the *Nespresso* Original coffee system under specific conditions, but a less responsible person could prepare a higher impact cup of coffee using the drip filter or moka coffee systems compared with the *Nespresso* Original. Thus, the *Nespresso* coffee system appears as a safeguard and stable solution against an environmental un-responsible use.

In summary, when comparing the different systems, capsule coffee systems can offer various benefits:

- *A precise use of resources:* the *Nespresso* system uses the exact amount of coffee, energy and water needed for each cup of coffee, so no resources are wasted unnecessarily during preparation.
- *Less risk of food waste:* The single-portioned coffee system ensures that only as much coffee is prepared as is actually consumed – hence no coffee grounds are wasted and no unused portions are thrown out.
- *High energy efficiency: Nespresso* machines need little time to be heated and are equipped with an automatic switch-off/standby function to reduce energy consumption.
- *Built-in usage consistency:* The performance of the *Nespresso* system eliminates the variations of consumer behavior with aspects such as automatic on/off switch and design to brew the exact amount of coffee in each capsule.
- *Recycling:* If the aluminium capsules are collected and returned to the *Nespresso* recycling system, the environmental balance is improved.

5. About the methodology and data used

The study worked with a variety of data sources. In addition to publicly accessible databases and studies, expert judgments and measurements from Quantis, primary data were available from *Nespresso* itself, especially for the *Nespresso* preparation system. For the alternative systems, on the other hand, publicly accessible data had to be used. Furthermore, the study did not investigate the environmental impact of different coffee varieties, growing regions or cultivation types.

Data for all systems were based on calculations for a standardized coffee that is average in European comparison. One major source of secondary data was the draft Product Environmental Footprint Category Rule (PEFCR) for the coffee sector. Product Environmental Footprint (PEF) is a European initiative to establish rules on how to perform LCA in various sectors, among others the coffee sector. This pilot on coffee stopped during the process but a draft document has been established and it contains a lot of useful data (PEF coffee Technical Secretariat, 2016[2]). The pilot stopped because no consensus was found about the labelling/comparison part, not because of the data. This draft document, including the part on data it contains, has been validated by the European Commission and the coffee stakeholders.

The electricity mix used for all activities occurring in Europe (including Switzerland) is the ENTSO-E mix (European Network of Transmission System Operators for Electricity), representing the average electricity mix consumed in Western Europe through the highly interconnected electric grid. For green coffee cultivation and treatment, the electricity consumed is based on the electricity mix from the different coffee production countries.

The packaging production for the *Nespresso* coffee system is based on primary data from *Nespresso*. For the full automat, drip filter and moka coffee systems, the packaging data come from the PEFCR study for coffee for the composition and on own measurement for the mass.

In this work, environmental impacts are assessed through six indicators corresponding to midpoint and endpoint level indicators and they are aligned with international guidance on life cycle assessment: greenhouse gas emissions, non-renewable resources depletion, land use, impact on ecosystem quality, water withdrawal, and human health.

Quantis compiled the data for each coffee system and evaluated them for the respective environmental impacts according to defined formulas. This was based on the consumer ritual, i.e. the consumption of two cups a day, at home in Switzerland. This assumption and data basis formed the basis for all statements and

[2] https://webgate.ec.europa.eu/fpfis/wikis/pages/viewpage.action?spaceKey=EUENVFP&title=Stakeholder+workspace%3A+PEFCR+pilot+Coffee

comparisons made in the study. If variables such as different types of coffee, machine types or consumer behavior are changed, this can lead to different results. The study also looked exclusively at the specific conditions of the Swiss market - for example regarding recycling. Consequently, the results are not easily transferable to other markets.

It is important to note that LCA does not exactly quantify the real impacts of a product or service due to data availability and modelling challenges. For the current assessment, the following limitations should be considered:

- The *Nespresso* coffee system is modelled with a more details and granularity because primary data were available for this model. As one of the purposes of the study was to understand better the impacts of the *Nespresso* coffee system, it was decided to keep all available data on this system, even if it was not possible to find as detailed data for the comparative systems. This is also the rationale that led to include life cycle stages with the same impacts for all systems, e.g., the overheads or the cup washing.
- This study focuses on the Swiss market and the results observed are therefore true only for this specific market.
- The green coffee cultivation is assessed following the PEFCR for coffee and the same coffee is applied for all systems. If one of the systems is sourcing from completely different origins, or from farms with completely different practices, this could lead to differences of production, less or more land use change impacts, or lower or higher delivery distances.
- Biogenic CO_2 uptake and release from the coffee (i.e., CO_2 that is consumed by the coffee plant while growing and released at the end-of-life when coffee grounds decompose or are incinerated) has not been included. However, it is accepted that all the coffee will be (almost) entirely degraded at end-of-life for composting, methanization and incineration and therefore that the balance is neutral for these end-of-life routes. There is no landfilling for municipal waste in Switzerland, so this was not included as an option in the study.

These limitations of the LCA results do not challenge the main conclusions relative to the defined goal and scope of the study, as the results still allow the identification of the key environmental parameters and key differences among scenarios.

This study is compliant with ISO 14040/14044 standards and its methodology, database and results have been critically examined by the following three independent experts, who found the results to be clear and transparent:

- Roland Hischier, EMPA (reviewer and chairman of the panel)
- Hélène Rochat, Topten International Services (reviewer)
- François Maréchal, EPFL (reviewer)

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This report has been prepared by the Swiss office of Quantis. Please direct all questions regarding this report to Quantis Switzerland. www.quantis-intl.com

6. Glossary

AAA	Nespresso AAA Sustainable Quality™ Program The Nespresso AAA Sustainable Quality™ Program was launched in 2003 with the NGO the Rainforest Alliance. It is based on internationally recognized social and environmental sustainability criteria. It fosters long term relationships with farmers, embeds sustainable practices on farms and the surrounding landscapes, and improves the yield and quality of harvests. At the same time, it contributes to improve the livelihoods of farmers and their communities.
ASI	Aluminium Stewardship Initiative
Carbon footprint	The carbon footprint is a measure of the potential impact on climate change. It takes into account the capacity of a greenhouse gas to influence radiative forces, expressed in terms of a reference substance and specified time horizon (100 years). The impact metric is expressed in kg CO_2-eq.
Biogenic CO_2	Plants photosynthesis consumes CO_2. When released, e.g., when the plant is composted or incinerated, this CO_2 is specified as biogenic CO_2. As the quantity released has been before pumped by the plant, the balance is considered to be neutral. This is true only when the carbon is released as CO_2, but not when it is released as methane that has a higher global warming potential than CO_2.
Distribution	The distribution life cycle stage covers the transportation of the production from the manufacturing site to the consumer.
End of life	The end-of-life stage includes the collection and treatment of the different packaging items, the coffee grounds, the machine and the cup.
ENTSO-E	European Network of Transmission System Operators for Electricity
Green coffee supply	The study analyzes the complete coffee cultivation, including agrochemical use, irrigation, possible deforestation, energy and water consumption for coffee cherries processed into green beans and transport to Europe.
ISO	International Organisation for Standardization
LCA	Life Cycle Assessment
LCIA	Life Cycle Impact Assessment
Manufacturing	The manufacturing stage includes the energy, water, gases, building, machinery that are needed for the processing of green coffee into roast and ground coffee. The wastes generated and their treatment are also considered.
Net impact	The net impacts is the sum of impacts and credits.
OEF	Organisation Environmental Footprint
Overheads/support	The overheads for Nespresso include the activities related to the global headquarter administrative center, the Swiss market head office, the Swiss after sales centers and the Swiss call center. The same data are considered for the Overheads/support for all coffee systems studied.
Packaging production & delivery	The packaging production includes the production of the materials and their forming for the primary, secondary and tertiary packaging.The primary packaging corresponds to the capsule for the Nespresso coffee system and a laminated pouch of 500 g roast and ground coffee for the full automat, drip filter and Moka coffee systems. The secondary packaging corresponds to the sleeve containing 10 capsules for the Nespresso and a carton board tray containing several pouches for the full

	automat, drip filter and Moka coffee systems. The tertiary packaging consists in a corrugated board box, a pallet and an LDPE film for all systems.
PEFCR	Product Environmental Footprint Category Rule
PEF	Product Environmental Footprint
Use	The use stage includes the machine production fraction, the cup production, the coffee brewing (machine use), the machine cleaning and the cup washing. For the drip filter, the paper filter production and distribution are also included.