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

In 2022, *Nespresso* commissioned Quantis, a leading consulting firm specialized in sustainability, to perform a life cycle assessment (LCA) of a cup of coffee made from various coffee systems, at home, in France (metropolitan area). This study examined the life cycle of espresso and lungo cups 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 espresso and lungo cups of coffee prepared using the *Nespresso* Original system in France with the two different packaging designs: the aluminium capsule and the paper-based capsule. The study compared then this *Nespresso* system with other portioned and unportioned coffee systems such as: a new portioned coffee system using compostable coffee balls, a full automat, a moka and a drip filter.

This study has been adapted then to the European context and the present document summarizes the LCA adaptation made for the European market (made of 19 countries of interest: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and UK).
The present executive summary only depicts the outcomes of the study related to the 110 ml Lungo cups (not 40 ml espresso cups). As the *Nespresso* paper capsule does not yet exist for Lungo cups of coffee, it has also been removed from the present executive summary.

Conclusion
The conclusions of this LCA adaptation for the European market are in line with the main conclusions of the baseline study for the French market: the full automat has higher environmental impact than the *Nespresso* coffee system. Considering the scenarios studied for the different coffee systems, all selected portioned-based coffee systems in this LCA summary (the *Nespresso* Original and the coffee balls) have a similar carbon footprint within their cup size, which is generally lower than the carbon footprint of a Full automat coffee system for the same cup size. The drip filter coffee system has similar impacts than the other portioned-based coffee systems. The results also show that for all selected coffee systems, impacts are systematically dominated by the green coffee supply and the use stage.

ISO compliance
To follow the requirements of the International Organization for Standardization (ISO) 14040/ 14044 standards for a comparative assertion and public disclosure, this adapted LCA for the European market of *Nespresso* as well as the baseline comparative LCA study have been peer-reviewed by three independent experts:

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

1. Background and context

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 an adaptation for the European market of the baseline study called *"Life Cycle Assessment (LCA) of a cup of coffee made from a Nespresso Original capsule and other coffee systems in France".*

The objective of this study is to respond to the following key questions:

1) What is the impact of the different *Nespresso* Original preparation systems on the environment in Europe?
2) How do the various *Nespresso* Original coffee systems position compared to alternative coffee preparation systems used in Europe?

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 LCA adaptation to European market and the initial LCA report conform 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 2022.

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 adaptation?

The current study is based on the report "Life cycle assessment (LCA) of a cup of coffee made from a *Nespresso* Original capsule and other coffee systems in France" and was adapted to the European context. This study adaptation assesses the life cycle of a lungo cup of coffee prepared and consumed at home, in Europe. The study included the extraction of all raw materials and coffee cultivation through the end-of-life of all components, including packaging The study is carried out for the *Nespresso* Original system, prepared with aluminum capsules, as well as other portioned and unportioned coffee systems: new portioned coffee balls system, full automat and drip filter coffee. The products assessed for the French baseline study are kept for this adaptation on the European market.

Due to a lack of data availability related to green coffee cultivation and delivery for all systems, the coffee systems are being compared considering the same green coffee cultivation and delivery - partly based on primary data from *Nespresso* and partly based on generic data from the World Food LCA Database (WFLDB).
To achieve comparable results, the study assumes an average drinking habit of 2 cups of coffee per day at home. For all coffee systems compared in the current study, a preparation of a lungo cup of 110 ml was considered.

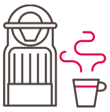
Nespresso

Nespresso Original coffee prepared with a mix of the three best-seller *Nespresso* machines: ***Nespresso*** **Essenza, Inissia and Citiz.** The mix is based on the sales volumes of the different *Nespresso* machines and corresponds therefore to a weighted average.

The *Nespresso* Original system uses portioned coffee to prepare espresso, ristretto or lungo coffees. The coffee comes in 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.

The packaging design of the *Nespresso* coffee system is made of an **aluminium-based packaging design** consisting in an aluminium capsule that is made using at least 80% recycled aluminium, a sleeve in solid board containing 10 capsules and a tertiary packaging consisting of a corrugated board box, pallet and LDPE film. This packaging design is called *NN alu* on the results charts.

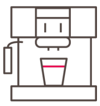
When the term "packaging design" is used, it means the full packaging system, i.e., the capsule (or primary packaging), the secondary packaging (i.e., the sleeve or pouch) and tertiary packaging.



Compostable coffee balls

Coffee prepared using a compostable coffee balls system. It's a portioned based system where the coffee ball is held together from a algae-based membrane. The coffee balls are sold in packs of 9. The tertiary packaging consists in a corrugated board box containing several packs of 9, a LDPE film and a pallet.

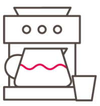
The coffee balls system uses portioned coffee to prepare espresso, ristretto or lungo coffees. The coffee comes in balls that are inserted in the machine. Water under high pressure is pumped through the coffee balls, and the brewed coffee flows through a funnel into the coffee cup.



Full Automat

Coffee prepared using a full automat coffee system, with the full automat machine most commonly sold in France kept for this adaptation.

A full automat coffee system can produce various types of coffee fully automatically. 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. The coffee beans are packaged in plastic and aluminium laminated pouches, several pouches being packed in a corrugated board box and palletized.



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. The roasted and grinded coffee packaging is the same as for the coffee beans for the full automat.

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

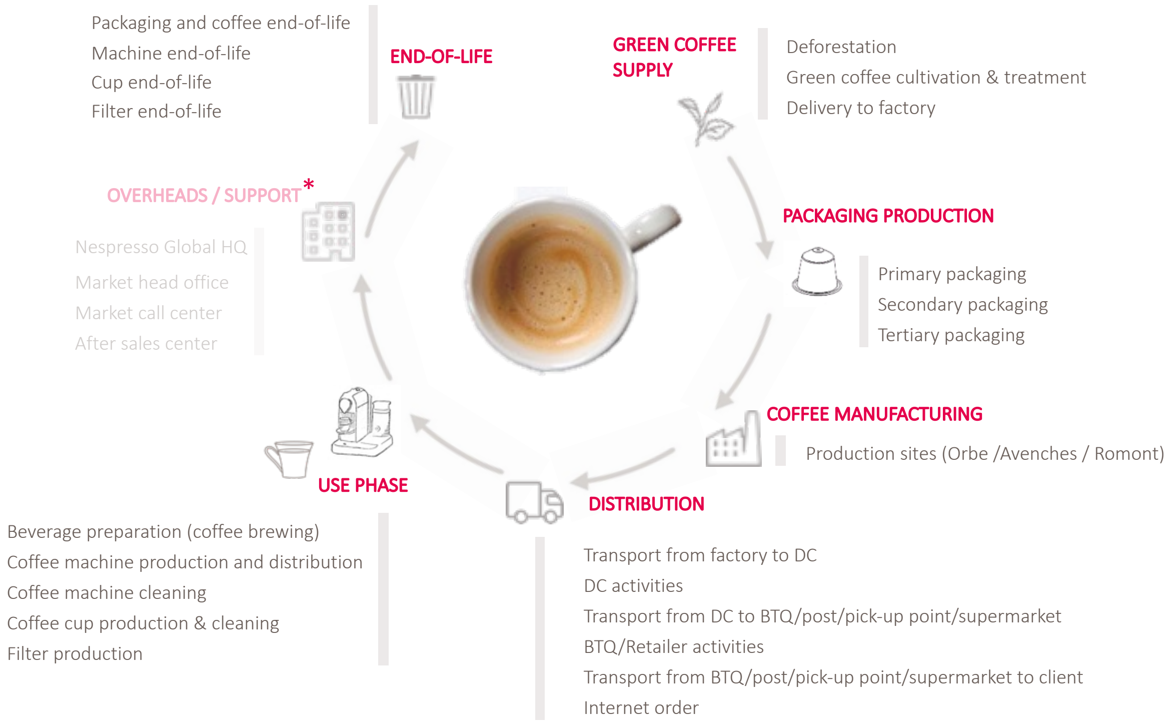


Figure 1: Life cycle of a cup of coffee (DC: distribution center, BTQ: boutiques, PU: pick-up points, HQ: head quarter).
**Overheads are not quantified in this report.*

- **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 all coffee systems assessed: a wide variety of coffee is available for other coffee 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.
  In the framework of this LCA adaptation, the amount of coffee was adapted for *Nespresso* aluminium to consider the amount in lungo capsule considering the different SKU available on the market and their sales volumes. For the other coffee systems, such data were not available and therefore the same coffee amount per cup were kept as in the baseline study assumptions. The same cultivation, cherries processing and coffee delivery models were used, i.e., the same coffee emission factor is applied as in the baseline study.

- **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 capsule for *Nespresso, the multilayer pouch for other coffee systems*), the secondary or outer packaging (e.g., sleeves), and the tertiary packaging used for the delivery (e.g., Europallet, or large cardboard boxes).
  In the framework of this LCA adaptation, this upstream stage of the life cycle of a lungo cup of coffee remains unchanged for all products.

- **Manufacturing**
  The examination includes all steps of further coffee processing such as roasting and grinding in the production sites. The same manufacturing process has been considered for all selected coffee systems. All coffee systems use roasted and ground coffee, while full automat uses coffee beans. It can be noted that grinding the beans is negligible in terms of energy consumption.
  In the framework of this LCA adaptation, no change was done for this life cycle stage compared to the baseline study.

- **Overheads/support**
  Overheads are assumed to be similar for all systems and were therefore excluded from this comparative LCA study (as in the main report).

- **Distribution**
  Includes the transport routes from production to the customer. In the case of *Nespresso*, the distribution can be via boutiques or pick-up points, including a shopping trip of the consumer, or via postal delivery.
  In the framework of this LCA adaptation, the transport from factories to distribution center was adapted to the European market, as well as the share of capsules distributed via post, boutiques or pick-up point for the *Nespresso* capsules. No modification is applied to the other coffee systems.

[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.

- **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 in a dishwasher.
  In the framework of this LCA adaptation, nothing was changed as the same machines are considered for the different systems.

- **End-of-Life**
  The final stage covers the collection, sorting and recycling of packaging materials, capsules and coffee grounds.
  In the framework of this LCA adaptation, various elements were updated to fit to the European context.
  - In Europe, municipal wastes sent to trash are to 53% incinerated[2] and 47% landfilled.
  - Due to the introduction of its own recycling system, *Nespresso* has reached a recycling rate of 30%[3] for the **Original aluminium** capsule in 2022 on the European market. This means that for 30% of the Original capsules, the capsules are collected with other aluminium waste and sent to various recycling stream where the aluminium is remelted to ultimately be recovered to produce secondary aluminium. When recycled, the coffee ground contained in the capsule goes to industrial composting (47%), to biodigester facility (37%) and into pyrolysis (16%). The remaining share of the capsules will be incinerated (37%) and the remaining fraction landfilled (33%).
  - For **Coffee Balls**, the leftover coffee grounds and membrane are fully compostable. The average scenario for organic wastes from the PEF method (2019) is considered: 50% trash (i.e., 50% incineration with energy recovery), 25% industrial composting, 25% methanization.
  - For the **full automat**, **moka** and **drip filter**, the pouch of R&G coffee is considered to be 100% trashed (no recycling process existing at large scale for that type of laminated material) as in the baseline study; and the average scenario for organic wastes is considered for the coffee ground (as described for Coffee balls).
  - For the cardboard packaging (sleeve or tertiary box), they are to 82% recycled in Europe[4].

The main changes compared to the baseline study are:

- Amount of R&G coffee for the *Nespresso* alu lungo cups as it is based on the weighted average considering the sales volumes in Europe instead of France.
- Share of *Nespresso* alu capsules distributed via post, boutiques or pick-up points are adapted to Europe as well as the distance from factories to distribution center.
- The fate of trashed waste (% landfilling and % incineration) were adapted as well as the *Nespresso* recycling share.
- The fraction of organic waste sent to methanisation, industrial/home composting, trash was updated as well as the cardboard recycling rate.

[2] https://ec.europa.eu/eurostat/databrowser/view/env_wasmun/default/table?lang=en
[3] Nespresso HQ data, 2022
[4] https://ec.europa.eu/eurostat/databrowser/view/env_wasmun/default/table?lang=en

3. Key results

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 withdrawal (throughout the whole lifecycle, not just in the use phase). A detailed interpretation of the carbon footprint indicators is performed hereafter as this indicator is well known and understood, and it is of importance for *Nespresso* as they have targets on this indicator. The main conclusions for the other indicators are in line with the conclusions for carbon footprint.

This chapter 3 of Key results, is divided in three sub-chapters:

- 3.1 is comparing the carbon footprint of the different systems studied: *Nespresso* Original, the Coffee balls, Full automat and Drip filter.
- 3.2 is comparing the coffee systems studied on other environmental indicators
- 3.3 is addressing the impact variability of the results for the systems studied

3.1 Carbon footprint performance of the examined coffee systems

For the lungo cups, with total GHG emissions of 105 g CO2-eq the Drip Filter coffee system has the lowest impact with respect to Climate change, while the Full auto. has the largest impact with 139 g CO_2-eq.
The *Nespresso* Original and the coffee balls systems have a very similar carbon footprint than the Drip Filter system with a carbon footprint respectively at 106 g CO2-eq and 107 g CO2-eq per lungo cup of coffee.

For all coffee systems and the two cup sizes, one of the primary drivers of the impacts on climate change is the green coffee supply (48% for *Nespresso* alu to 58% for the Full Auto. The use stage is also a significant driver of the impacts on climate change (34% for *Nespresso* alu to 41% for Drip Filter), for which the impact is shared between the cup production and washing (23% for *Nespresso* alu), followed by the coffee brewing (6% for *Nespresso* alu) and machine production, distribution and cleaning (5% for *Nespresso* alu). After these two categories, the packaging and distribution represent the next impactful category. Packaging shows some variation between the different systems ranging from 2% for the Full Auto. and Drip Filter to 11% for *Nespresso* alu, the latest being shared between the primary capsule packaging (9%) and the secondary and outer packaging (2%). Same for the distribution where the different systems are ranging from 1% for the for the Full Auto. and Drip Filter to 5% for *Nespresso* alu. The coffee manufacturing shows a small impact (≈1% for all systems). And finally, the end-of-life represents an impact of 0,7% for the Full Auto. to 1% for the *Nespresso* alu or even 1,7% for the coffee balls.

Lungo cup

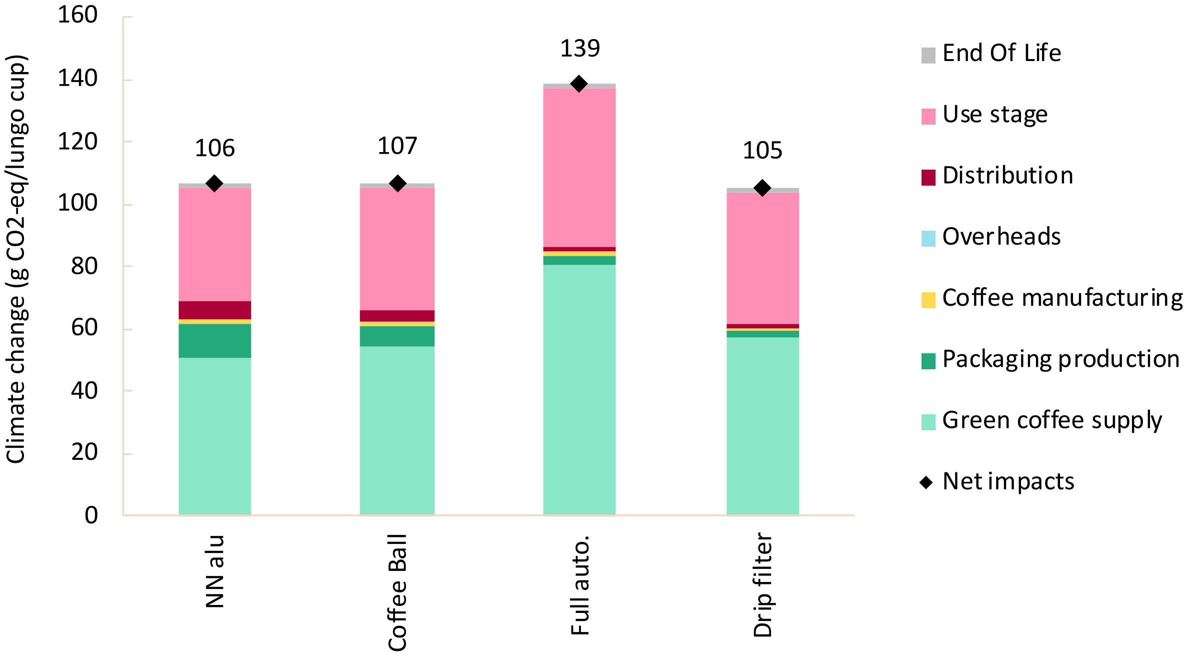


Figure 2: GHG emissions per life cycle stage for the selected coffee systems on the European market, for a lungo cup

3.1.1 Green coffee supply

The cultivation of coffee is the most important contributor to the greenhouse gas emissions of a cup of coffee. 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 (other coffee systems 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 lungo cup only (ranging 5.7 g for the *Nespresso* system, to 6.0 g for the coffee balls, 6,1g for Drip filter or 9.0 g for the Full auto. lungo). The contributors to this life cycle stage that are described in the baseline report are applicable for all coffee systems as the same green coffee is used for all in these 2 reports.

3.1.2 Packaging production and delivery

The coffee pouches (laminate of plastic and aluminium) used for the full automat and drip filter systems are assumed to be the same for but the amount of coffee per lungo cup varies, leading to a different fraction of pouch per cup of coffee for these 2 coffee systems. The impact for the packaging for these 2 systems ranges from 2 to 3 g CO_2-eq per cup. The impact for these non-portioned systems is proportional to the amount of coffee per lungo cup: using more coffee will mean that a higher proportion of the packaging is allocated to the cup.

The impact of portioned systems (*Nespresso* alu and Coffee balls) is systematically higher and ranges from 7 g CO_2-eq for the Coffee balls to 11 g CO_2-eq for *Nespresso* alu, and is due to the heavier packaging for portioned product compared to unportioned.

The baseline study demonstrated that when the primary packaging has lower impact for a portioned system (e.g., Coffee balls), this is balanced with more impacting secondary packaging, which leads to a final carbon footprint quite similar among the portioned systems.

It is important to keep the different end-of-life trajectories of the different materials in mind (e.g., the recycling of the aluminium leads to a GHG emissions benefit, while the incineration of the plastic pouches to an extra GHG emission load). Conclusions relative to the packaging performance should not be drawn without considering the packaging end-of-life.

3.1.3 Manufacturing

The Manufacturing stage contributes to ≈1% of the total greenhouse gas emissions, and it was modelled using the same process for all coffee systems. The same process based on *Nespresso* data is considered for all systems due to a lack of data for the other coffee systems. Given the wide variety of coffee that can be used for these other coffee 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: 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. 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. For this reason, the *Nespresso* alu has the lowest manufacturing impact (1 g CO_2-eq per cup) while the full automat has the highest (2 g CO_2-eq per cup).

3.1.4 Overheads / Support

Without specific data on the activities and services for the overheads of the individual brands, it has been decided not to differentiate the systems regarding the overheads impacts.
Overheads are assumed to be similar for all systems and were therefore excluded from this comparative LCA study.

3.1.5 Distribution

The carbon footprint of distribution ranges from less than 1 g (for the lungo prepared with the drip filter coffee system) to 6 g CO_2-eq (for *Nespresso* system).
The impact of *Nespresso* system is due to the fact the distribution center activities are based on *Nespresso* specific data which are more impacting than the generic distribution center considered for the products distributed via supermarkets. In addition, the distribution via boutiques is less efficient than by supermarkets based on the data and assumptions used. It must be noted that the *Nespresso* distribution center and boutiques impacts are based on data collected by *Nespresso* corresponding to the average *Nespresso* global market meaning that the European market could have better or worse impacts depending on e.g., its exact amount of energy consumed or energy mix.

3.1.6 The use stage

The use stage is the second most important contributor to climate change for all examined coffee preparation systems (from 34% to 41%). The cup production and washing has the largest contribution to the use stage carbon footprint (≈15g CO_2-eq-per cup), except for the lungo made with the full automat coffee system where impacts are dominated by the machine production due to its heavy weight (16 g CO_2-eq per cup). Impact caused during brewing represents from 2 to 6 g CO_2-eq per lungo cups, depending on the system considered. For drip filter, the paper filter production and distribution were also included and represent 4 g CO_2-eq per cup. The impact of the water filter production and distribution for the full automat system are low.

The use stage for the *Nespresso* system and the Coffee balls is very similar, even if the machine used is different. The use stage of the drip filter system leads to similar greenhouse gas emissions as the portioned systems: its brewing energy is higher, but the machines is much less impacting. The full automat coffee system is characterized by higher greenhouse gas emissions than other systems, mostly due to its heavier machine.

3.1.7 End-of-life

The end-of-life of the different coffee systems do all lead to net greenhouse gas emission impacts ranging from 1 g CO_2-eq to 2 g CO_2-eq. This net impact results from the sum of some benefits (explained by the medium recycling rate for the *Nespresso* aluminium capsule) and higher impacts (mostly explained by the landfilling of a significant part of the coffee ground for all coffee systems).

3.2 Comparing the *Nespresso* preparation system with other systems for other indicators

Lungo cup

Considering the other indicators assessed (non-renewable resources depletion, water withdrawal, ecosystem quality, human health and land use), the main contributors to the impacts of a cup of coffee are dominated by the same stages as for the climate change: the green coffee supply and the use stage are the most important contributors, except for the Land use indicator, where green coffee supply and packaging production are the main hotspots. Figure 3 visualizes the contribution of individual life cycle stages for all lungo coffee systems and all 6 analyzed indicators.

3.2.1 Non-renewable resources depletion

Based on Figure 3, the Non-renewable resources depletion indicator shows the main contribution from the use stage, closely followed by the green coffee supply. This indicator is driven by substances such as coal, oil, gas, etc. and gold, silver, lead etc., and therefore directly reflects the use of fossil fuels and minerals over the coffee cup life cycle.
The green coffee supply impacts are due to the energy consumed for the coffee cherries treatment and to the energy consumed in the fertilizers production.
For the use stage, the impacts are related to the cup washing (dishwasher use), the coffee brewing and the machine production (electricity use plays an important role for this indicator).

3.2.2 Water withdrawal

As shown in Figure 3, it appears that the Water withdrawal indicator is mostly driven by the green coffee supply, which is directly related to the water needs for coffee irrigation purposes. The water use for the use stage - coffee preparation (110 ml), cup washing in dishwasher and water needs for electricity production – and water withdrawal from packaging production represent the other relevant categories.

3.2.3 Ecosystem quality

The part of Figure 3 on Ecosystem quality shows that the green coffee supply appears as the main contributor with a much lower contribution from the other stages.
Most of the impacts of the green coffee supply are due to the direct field emissions (ammonia, dinitrogen monoxide, phosphate) resulting from the use of fertilizers. These emissions have acidifying effects (ammonia and dinitrogen monoxide) or eutrophication effects (phosphate) leading to Ecosystem quality decrease.

3.2.1 Human health

Looking at Figure 3, it appears that the life cycle stages contribution for the Human health indicator follows a similar trend as the Climate change indicator. Green coffee supply and use stage are the largest contributors.
The impacts for the green coffee supply are driven by the ammonia emitted in the cultivation area due to the nitrogen-based fertilizers applied. The second contributor for this stage is the emission of particulate matter (<2.5 um) that is related mainly to fossil fuels burning and therefore to the energy consumption, either direct energy use at farm for cherries treatment and irrigation or indirect energy consumption for the fertilizers production.

Impacts on use stage are mostly related to the manufacturing of the coffee machine, the manufacturing of the dishwasher as well as the cleaning of the coffee cup. The machine production impacts are related mostly to the metals and electronic parts: their production consumes a lot of energy (fossil fuels burned, i.e., particulate matter emissions and respiratory effects) and specific metals, e.g., gold, which production emits heavy metals at mine (in the case of gold, arsenic emissions from the tailings). The heavy weight of the Full auto. machine explains the larger impacts associated to this coffee system among the other systems.

3.2.2 Land use

Looking at Figure 3, it appears that the impact on land use is dominated by the green coffee supply, followed by the packaging production.
The large contribution of the green coffee supply stage is associated to the use of land for the green coffee cultivation. The contribution of the packaging production stage is largely explained using land for forests which deliver the wood fibers necessary to produce the paper and cardboard packaging.

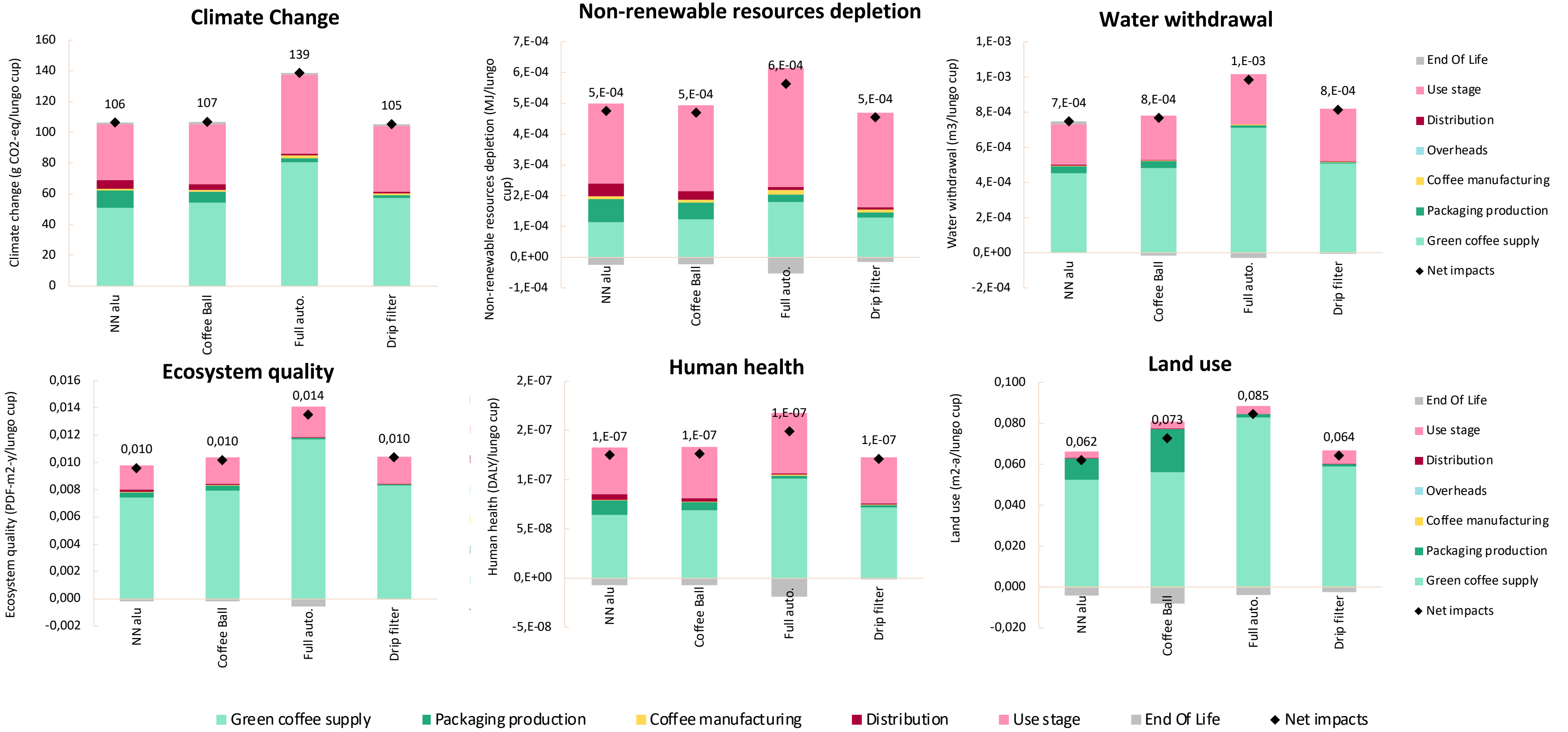


Figure 3: Life cycle stages contribution for the compared lungo coffee systems for all impact indicators on the European market.

3.3 Assessing impact variability through sensitivity analyses

For the baseline study, several sensitivity analyses have been performed for all systems according to ISO requirements. Analyses were performed on e.g., the amount of coffee used (higher or lower amount per lungo cup), on the energy consumption for preparation (machine efficiency) or on the end-of-life of capsules (e.g., 0-100% recycling for aluminium capsules). Results were combined into a best and a worst combination of these assessed parameters (only including scenarios that can be influenced by good or bad consumer behavior). The analysis shows that all portioned coffee systems are generally better performing than The Full auto. coffee system (even when comparing best case of Full auto. against worst case from portioned systems).

The description of the individually assessed scenarios, the best and worst combination of scenarios as well as the corresponding assumptions and data that are used can be found in the baseline report for the French market (same sensitivity analyses are performed).

Generally, it can be said, that unportioned coffee system performances are much more dependent on consumer behavior than portioned coffee systems. Furthermore, it can be observed that portioned coffee systems show a better performance that the Full auto. system (regardless of the scenario).

4. Conclusion

Comparison of the different coffee systems

The holistic view on the life cycle of the different coffee preparation systems studied, shows that drinking a 110 ml lungo cup of coffee made from a *Nespresso* coffee system with aluminium packaging in Europe has a similar environmental impact as the same cup of coffee made Coffee balls system, or Drip filter coffee system. A lungo cup prepared by a Full auto. coffee system has higher impacts across all six environmental indicators.

Main contributors to a cup of coffee environmental impact

A large part of the impact on the environment is rooted in the cultivation of the green coffee and coffee preparation at home (cup production and washing, brewing of the coffee, machine production, distribution and cleaning). The environmental impact of coffee consumption increases when consumers do not dose exactly, throw out left-over coffee, or use inefficient machines. Unportioned coffee systems 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 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 coffee systems compared with the *Nespresso* Original.

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. 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[5]). 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 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 capsules is based on primary data from *Nespresso*. For the full automat and drip filter 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 Europe. This assumption and data basis formed the basis for all statements and 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.

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:

- This study adaptation focuses on the European market and the detailed results observed are therefore true only for this specific market.
- The *Nespresso* coffee capsules are modelled with more details and granularity because primary data were available for these models. As one of the purposes of the study was to understand better the impacts of the *Nespresso* coffee capsules, it was decided to keep all available data on these systems, 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.

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

- Emissions from overheads (activities and purchased activities) are excluded from this study. Without primary data from the different coffee brands these impacts are considered to be the same for all coffee systems and can therefore be excluded from this comparative LCA study.
- The green coffee cultivation is assessed using generic data from the WFLDB adapted to *Nespresso* origins and practices 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.
- The processing for the different packaging alternatives is modelled based on assumptions and proxies (except for the *Nespresso* aluminium capsule for which it is partly based on primary data). Using primary data collected from suppliers would improve the processing model and refine the packaging production impacts.
- 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. Indeed, it is accepted that all the coffee will be almost entirely degraded at end-of-life leading to a nearly neutral balance, and when it was not the case (e.g., part of carbon sequestered in landfills), then a benefit was added.
- The composting and methanisation impacts and benefits are based on a Quantis internal model which considers the composition of the biodegradable wastes to calculate the emissions and benefits. This model is based on literature and best available knowledge but could be refined based on experimental data, especially the exact degradation rate of the different materials in industrial or home composting.

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.

The baseline study and adaptation to European market are 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)
- Nadja Gross, Topten International Services (reviewer)
- François Maréchal, EPFL (reviewer)

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

6. Data

Data considered to model Green coffee supply, Distribution and End-of-life is available upon request.

7. Glossary

AAA	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.
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 (EoL)	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 are the sum of impacts and credits.
NN	Nestlé Nespresso
OEF	Organisation Environmental Footprint
Overheads/ support	The overheads for *Nespresso* include the activities related to the global headquarter administrative center, the European market head office, the European after sales centers and the European 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 & Moka coffee systems. The tertiary packaging consists in a corrugated board box, a pallet and a LDPE film for all systems.
PEF / PEFCR	Product Environmental Footprint / Product Environmental Footprint Category Rule
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.