Quantis

LIFE CYCLE ASSESSMENT (LCA) OF AN ESPRESSO CUP OF COFFEE MADE FROM A NESPRESSO PROFESSIONAL CAPSULE COMPARED WITH OTHER COFFEE SYSTEMS IN FRANCE

In 2019, *Nespresso* commissioned Quantis, a leading consulting firm specialized in sustainability, to perform a life cycle assessment (LCA) of a cup of espresso coffee (40 ml) made from various coffee systems, in a business environment, 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 an espresso cup of coffee prepared using the *Nespresso* Professional system in Switzerland compared with two other coffee preparation systems: the full-automat system (considering one efficient system and one non-efficient system) and the soluble with kettle coffee system.

Two use scenarios have been tested: a case of a business consuming 4 000 cups per year and machine, and a case with a higher coffee consumption of 10 000 cups per year and machine. The type of machine used for these different use intensities is different, both for Nespresso (recommending a machine called Zenius for the 4 000 cups/year and the machines Gemini or Momento for the more intensive use of 10 000 cups/year) and for the full automat machines.
For the full automat machines, given the wide range of available machines on the market, two different alternatives have been chosen among machines widely sold on the Swiss market, one representing an efficient machine and one a non-efficient and this for the two use intensities of 4 000 and 10 000 cups per year. The soluble coffee system remains the same whatever the number of cups prepared per year.

In the framework of this study, a specific scenario has been established for *Nespresso France* in order to adapt the final comparative LCA results to the French market (metropolitan France for the context of this study).
The present document summarizes the LCA adaptation made for the French market; it describes the main assumptions and conclusions applicable to the market.

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

The conclusions of this LCA adaptation for the French market are in line with the main conclusions of the baseline study for the Swiss market: considering the scenarios studied for the different coffee systems, the *Nespresso* Professional system has lower carbon footprint than the full automat systems assessed but a higher carbon footprint than the soluble coffee.

To follow the requirements of the International Organization for Standardization (ISO) 14040/ 14044 standards for a comparative assertion and public disclosure, this LCA adaptation for the French market of *Nespresso* as well as the baseline comparative LCA study have 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. Then 10 years later, *Nespresso* revolutionized coffee culture in business environment with the creation of the Professional capsule and associated machines.

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 France* commissioned Quantis, an international sustainability consultancy, to carry out an adaptation for the French market of the Life Cycle Assessment (LCA) of an espresso cup of coffee (40 ml) made and consumed in Switzerland. The current adaptation aims to respond to two key questions:

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

1.1 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.

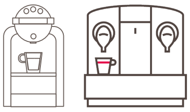
The present LCA adaptation to French market and the initial LCA report conform to the International Organization for Standardization (ISO) 14040/ 14044 standards for a comparative assertion and public disclosure and has been peer-reviewed by independent experts from the Swiss Federal Laboratories of Materials, Science and Technology (EMPA), Topten International Services and the Swiss Federal Institute of Technology in Lausanne (EPFL). Its results are representative of the year 2019.

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 an espresso cup of coffee (40 ml) prepared and consumed in a business environment, in France. 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* Professional coffee preparation system, as well as two other coffee systems: full automat and soluble coffee. 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 also following data outlined in the Draft PEFCR coffee.

Coffee is consumed differently in every business environment. In order to achieve comparable results, the study assumes two frequencies of coffee consumption: 4 000 cups/year-machine and 10 000 cups/year-machine. For all coffee systems compared in the current study, a preparation of a 40 ml espresso cup of coffee was assumed.



Nespresso

Nespresso Professional espresso capsule prepared with the three Nespresso machines suitable for the following scenarios:

- 4 000 cups/year frequency: ***Nespresso* Zenius**
- 10 000 cups/year frequency: ***Nespresso* Gemini CS200** and ***Nespresso* Momento 100**

The *Nespresso* Professional system uses portioned coffee to prepare espresso. The roast and ground coffee comes in laminated "pods" 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 full automat coffee system, one efficient system and one non-efficient system from energy consumption standpoint have been initially selected among the three most sold machines on the Swiss market, for both frequencies of coffee consumption. Producers of these coffee machines are selling internationally and their coffee machines can commonly be encountered on the French market. The machines selected do not include milk refrigeration compartment as black coffee is assessed.

- 4 000 cups/year frequency:
  - Efficient system: **Jura ENA MICRO 1**
  - Non-efficient system: **Delonghi Magnifica ECAM 350.75.SB.**
- 10 000 cups/year frequency:
  - Efficient system: **Jura WE6**
  - Non-efficient system: **Franke A200 MS EC**

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.

Soluble Coffee

Coffee prepared using soluble coffee with an average electric kettle following data outlined in the **Draft PEFCR coffee.**

A spoon of soluble coffee taken from a soluble coffee glass jar and poured in an espresso cup. The sufficient amount of water is heated using the electric kettle and is then poured in the espresso cup as well.

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

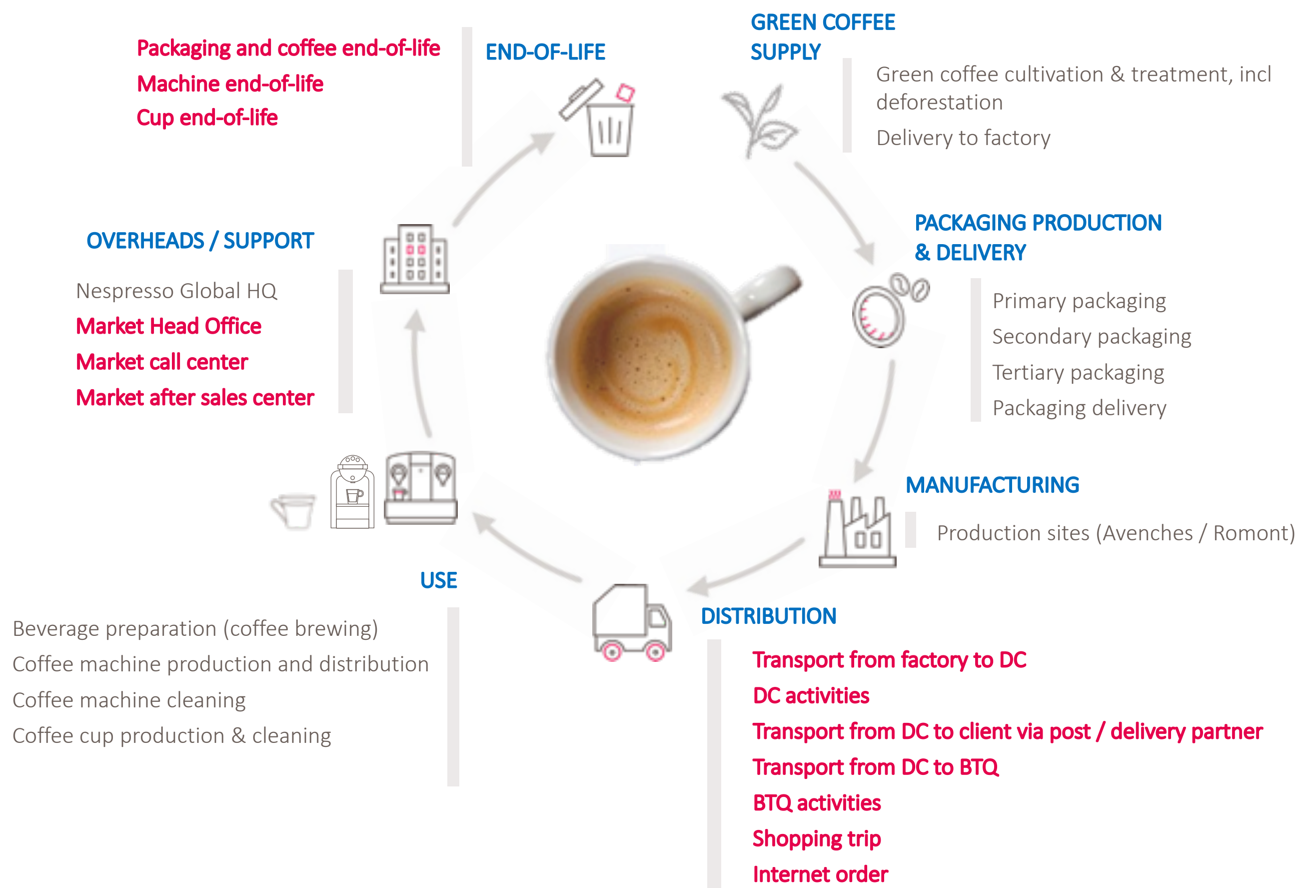


*Figure 1: Life cycle of an espresso cup of coffee (DC: Distribution Center, HQ: Head Quarter, BTQ: Boutiques) – in **red** are the activities adapted for the French market. The electricity mix for the use stage has only been adapted in the framework of sensitivity analysis performed in chapter 3.4.*

- **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 three coffee systems assessed: a wide variety of coffee is available for the full automat and soluble 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, this upstream stage of the life cycle of a cup of coffee remains unchanged regardless of the market considered.
- **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 laminated capsule for *Nespresso,* the multilayer pouch for full automat coffee systems and the glass jar for the soluble coffee), the secondary or outer packaging (e.g. sleeves), and the tertiary packaging used for the delivery (e.g. Europallet or large cardboard boxes).

[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.

In the framework of this LCA adaptation, this upstream stage of the life cycle of a cup of coffee remains unchanged regardless of the market under consideration.

- **Manufacturing**
  The examination includes all steps of further coffee processing such as roasting and grinding in the production sites of Orbe, Avenches and Romont for *Nespresso*. The same manufacturing process has been considered for the full automat and *Nespresso* systems, even if the full automat uses coffee beans and *Nespresso* roast and ground coffee. It has been confirmed by coffee experts that the grinding has a negligible contribution in terms of energy consumption compared to the roasting. The soluble coffee manufacturing is based on secondary data from the World LCA Food Database.
  In the framework of this LCA adaptation, this upstream stage of the life cycle of a cup of coffee remains unchanged regardless of the market under consideration.
- **Distribution**
  Includes the transport routes from production to the customer. In the case of *Nespresso*, the distribution can be via postal delivery or via delivery partners. For the full automat and soluble coffee, the distribution via delivery partners is considered as the partners providing *Nespresso* capsules also suggest roasted coffee beans and other type of coffee solutions to their clients.
  In the framework of this LCA adaptation, this stage of the life cycle of a cup of coffee has been modified in order to consider distribution distances and transportation means applicable for the French market.
- **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. All coffee systems need a cup to be produced and washed when drinking a cup of coffee.
  In the framework of this LCA adaptation, this downstream stage of the life cycle of a cup of coffee remains unchanged for the French market as the average European electricity mix was used for the baseline study and is applicable also for the French market.
- **Overheads/support**
  In this stage, aspects related to the backbone of the company are analyzed, for example, the *Nespresso* headquarters in Lausanne, the French head office or French call center. 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.
  In the framework of this LCA adaptation, this stage of the life cycle of a cup of coffee has been modified in order to consider overheads activities applicable for the French market.
- **End-of-Life**
  The final stage covers the collection, sorting and recycling of packaging materials, capsules and coffee grounds. In France, municipal wastes are on average 63% incinerated and 37% landfilled (Eurostat 2018 data). Due to the introduction of its own recycling system, *Nespresso* has reached a recycling rate of 20% for the capsules in 2019 on the French market. This recycling rate is a conservative value, as on top of these 20%, there are capsules collected and recycled through the collective recycling system in France (to which 35% of consumers have access to in 2021, and 50% of consumers will have access to in 2022).
  This means that for 20% of the *Nespresso* capsules, the aluminium will be re-melted to produce secondary aluminium and the coffee ground will be sent to a biodigestion facility, with the biogas used as fuel in buses, the digestate composted and used as fertilizers and the CO_2 recovered and used in greenhouses. The remaining share of the capsules will be incinerated (50%) or landfilled (30%).
  The capsule recycling rate is a primary data provided by Nespresso France.

Tables summarizing the main data changes from the baseline study to this French market adaptation are presented at the end of this executive summary.

3. Key results

The life cycle assessment of an espresso 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). 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 conclusions for the others indicators are in line with the conclusions for carbon footprint.

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

- 3.1 is detailing the carbon footprint of the Nespresso Professional system only.
- 3.2 is comparing the carbon footprint of the three different systems studied
- 3.3 is comparing the three systems studied on other environmental indicators
- 3.4 is addressing the impact variability of the results for the three systems studied

3.1 Carbon footprint of the *Nespresso* Professional system

A 40 ml cup of *Nespresso* coffee emits from 85 to 90 g CO_2-eq on the French market (depending on the use intensity considered: 4 000 cups/year or 10 000 cups/year). The carbon footprint of a *Nespresso* espresso is dominated by the green coffee supply (40% to 42% depending on the *Nespresso* machine considered) and the use stage (30% to 34% depending on the machine used). Overheads & support contributes to 8% of the greenhouse gas emissions of the *Nespresso* preparation system, similar to the packaging production (7 to 8%). The manufacturing and distribution follow with respectively 2% and 6%. End-of-life treatment – namely the recycling, incineration or landfilling of the capsules and other packaging items – contributes to 2% of the carbon footprint.

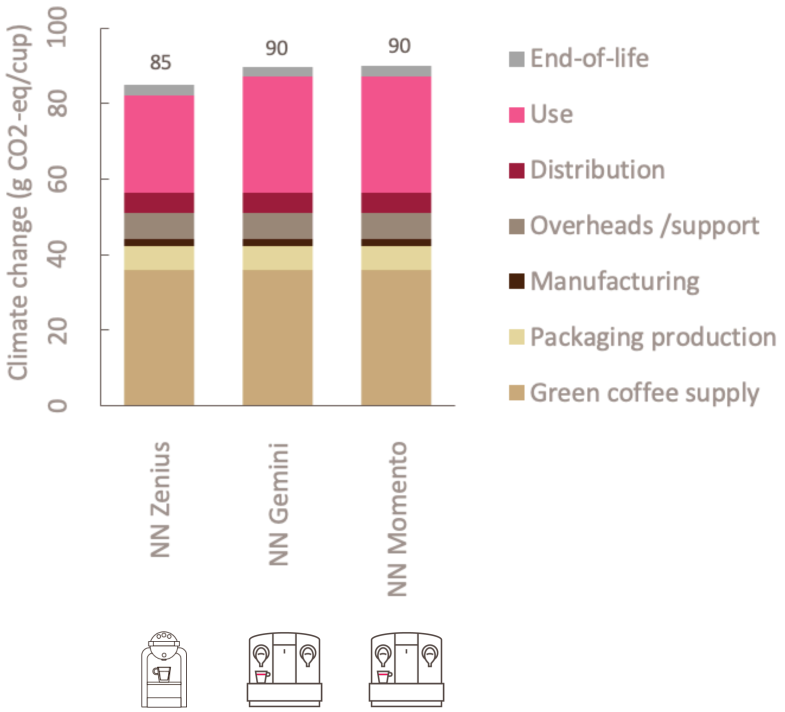


Figure 2: GHG emissions per life cycle stage for a Nespresso espresso (40 ml) cup of coffee on the French market (NN = Nestlé Nespresso)

3.1.1 Green coffee supply

The *Nespresso* coffee capsule contains in average 6.1 g of ground coffee to make an espresso (40 ml) cup of coffee. Considering the coffee grounds in one espresso *Nespresso* capsule, the green coffee supply accounts for 40% to 42% of the total carbon footprint of a cup of *Nespresso* coffee (36 g CO_2-eq/cup). Fertilizer use (14 g CO_2-eq) and land use change[1] (13 g CO_2-eq) are the largest contributors 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 3 g CO_2-eq of the carbon footprint for this stage.
The work on coffee sourced through the AAA Sustainability Quality Program should continue and also focus on fertilizers and pesticides use reduction keeping the same yield, use of renewable energy for coffee cherries processing, good coffee pulp management options, etc. despite these recognized efforts are not taken into account in the current study.

3.1.2 Packaging production and delivery

With 4.7 g CO_2-eq, the laminated capsule (0.52 g) is the main contributor to the packaging production and delivery. The contribution of the secondary (sleeves) and tertiary packaging (large corrugated board box, pallet and film) represents 1.7 g CO_2-eq.

The current study notes that if the capsule would be made of aluminium produced using 100% renewable energy, which would lower the greenhouse gas emission of the system by approx. 1.4 g CO_2-eq.

3.1.3 Manufacturing

This life cycle stage causes 2% of the carbon footprint (2 g CO_2-eq/cup) of a cup of 40 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 a weighted average of the production centers of *Nespresso* in Orbe, Avenches and Romont, in Switzerland. The carbon footprint score for this life cycle stage is mostly due to the natural gas consumption, the carbon dioxide 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).

3.1.4 Distribution

About 6% of the total greenhouse emissions (5 g CO_2-eq) are emitted in the distribution stage (compared to 2 g CO_2-eq in the Swiss study; differences are mainly due to higher distances and different means of transportations on the French market). For the *Nespresso* Professional capsules, the distribution can be done either via boutiques or via postal delivery. 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’ location. The electric consumption related to the internet use for the order is also included. The distribution via boutiques is applied only to a very small fraction of capsules (0.3%). It includes the transportation to boutiques, the boutiques activities and the shopping trip. Most of the carbon footprint for this stage is due to the transport from distribution center to post by van.

3.1.5 Use stage

The second contributor to the carbon footprint of an espresso cup of *Nespresso* coffee is the use stage, more precisely the cup production and washing (18 g CO_2-eq). 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 (4 to 10 g CO_2-eq depending on the *Nespresso* machine). If a consumer's energy supply in the office environment is based on renewable instead of non-renewable electricity, this could lead to a decrease in impact per cup of 3 to 7 g CO_2-eq in the coffee brewing stage depending on the *Nespresso* system considered. The machine production and distribution are the least impacting factors (3 to 4 g CO_2-eq depending on the *Nespresso* machine).

3.1.6 Overheads / Support

8% of the total greenhouse gas emissions (7 g CO_2-eq/cup) come from the overheads and support stage, depending on the *Nespresso* system considered (this impact is very similar to the one in the Swiss study). The overheads for *Nespresso* include the activities related to the global headquarters administrative center, the French head office, the French after sales centers, the French call center and the activities related to the Professional capsules sales. 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 3 g CO_2-eq/cup).

3.1.7 End-of-life

The end-of-life is a sum of various contribution inducing impacts (e.g. landfilling of coffee ground that ultimately lead to some release of methane in the atmosphere) or benefits (e.g. recycling of aluminium which finally avoid primary aluminium production).
The end-of-life of the *Nespresso* capsules (considered to be 20% recycled, 50% incinerated with energy recovery and 30% landfill on the French market) leads to a greenhouse gas emission net impact of 3 g CO_2-eq. A higher recycling rate would improve the environmental performance and a 100% recycling rate would reduce the carbon footprint of the cup of 6 g CO_2-eq.
The end-of-life treatment of the secondary and tertiary packaging, of the machine and the cup has only a very small contribution to the end-of-life greenhouse gas emissions.

3.2 Carbon footprint of the three examined coffee systems

For all coffee systems, impacts on climate change are systematically dominated by the green coffee supply (38% to 55%) and the use stage (26% to 34%), especially the cup washing in a dishwasher. They have a greater impact on the greenhouse gas emissions than overheads, which ranks third (7% to 10%) and packaging, which ranks fourth (4% to 8%). These four stages represent from 86% to 92% of the total greenhouse gas emissions of a 40 ml espresso cup of coffee made and consumed in France. The remaining 8% to 14% consists of the end-of-life stage, the manufacturing and distribution.

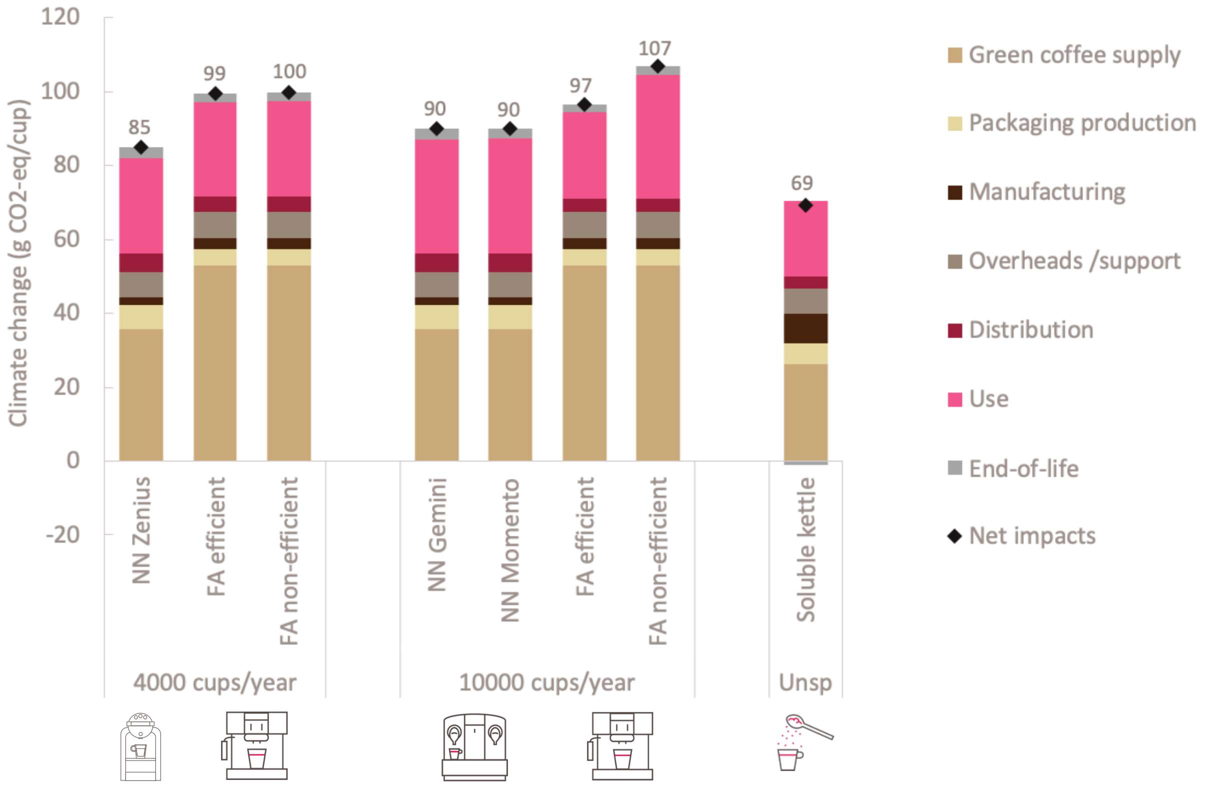


Figure 3: GHG emissions per life cycle stage for the compared coffee systems on the French market. The three first systems correspond to a use scenario of 4 000 cups/year while the 4 next correspond to the use scenario of 10 000 cups/year. The soluble coffee scenario is independent from this use intensity

Based on the studied coffee system carbon footprint, it can be mentioned that *Nespresso* system has lower impacts than full automat systems (except when a very efficient full automat is used, in this case the impacts are similar) but higher impacts than the soluble coffee system.

When comparing *Nespresso* to the full automat coffee systems, it appears it has a lower carbon footprint or a similar when compared to a highly efficient full automat machine (FA efficient for 10 000 cups/year). This is nearly entirely due to the lower amount of roasted and ground coffee per cup (9 g for the full automat and 6.1 g for the *Nespresso* system). *Nespresso* performs also better regarding the manufacturing (because a lower amount of coffee has to be roasted and ground per cup of coffee) and it has similar, better or worst performance for the use stage depending on the efficiency of the full automat it is compared with. Regarding the packaging or the distribution, *Nespresso* has a higher carbon footprint than the full automat system. The two systems have the same or very similar carbon footprint for the overheads/support and the end-of-life.

Nespresso has a higher carbon footprint than the soluble coffee, mainly explained by the higher amount of green coffee needed per cup of coffee, and the higher use stage impacts (capsules machines are more impacting to produce than kettles and the *Nespresso* machine energy consumption for coffee preparation is higher than the use of a kettle). The carbon footprint of the *Nespresso* packaging is also slightly higher than for the soluble coffee packaging. The distribution for the *Nespresso* system has higher greenhouse gas emissions than for the soluble coffee. On the contrary, the manufacturing impacts on climate change are higher for the soluble coffee due to the higher level of transformation of the product.

3.2.1 Green coffee supply

The cultivation of coffee has the 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 and soluble coffee 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 full automat having the highest amount of coffee beans per cup (9 g) has the highest carbon footprint, while the soluble coffee that needs the lowest amount of green coffee per cup has the lowest carbon footprint for this stage. The contributors to this life cycle stage that are described in section 3.1.1 above are applicable for all coffee system as the same green coffee is used for all.

3.2.2 Packaging production and delivery

The coffee pouches (laminate of plastic and aluminium) used for the full automat system, and the glass jar with PP cap used for the soluble coffee system have been modelled according to recommendations from the draft PEFCR for coffee. The impact of the *Nespresso* coffee system in the packaging stage is slightly higher than for the other two coffee systems. The difference for packaging production among the 3 packaging types is of 0.5 to 2 g CO_2-eq/cup, which is finally quite low in comparison with the full life cycle carbon footprint.

3.2.3 Manufacturing

The Manufacturing stage contributes to about 2% (2 g CO_2-eq/cup) of the total greenhouse gas emissions for the *Nespresso* and full automat systems while it reaches 11% (8 g CO_2-eq/cup) for the soluble, due to the higher contribution of processing green coffee beans into soluble coffee. The same process is considered for *Nespresso* and full automat due to a lack of data for the full automat. Given the wide variety of coffee that can be used for this system, the manufacturing could vary. *Nespresso* uses 100% renewable electricity for its manufacturing, it was seen as a conservative assumption to consider the same for the 2 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.

The soluble coffee manufacturing was based on a different processing as the transformation of green coffee into spray dried coffee consumes much more energy than roasting. This leads to a higher contribution of the manufacturing stage for the soluble coffee compared to the *Nespresso* and full automat systems.

3.2.4 Distribution

This stage emits about 3-5 g CO_2-eq for all coffee systems and is driven by the transport activities.

3.2.5 The use stage

The use stage has the second greatest greenhouse gas emissions for all examined coffee preparation systems. The cup production and washing has the largest contribution to the use stage carbon footprint (18 g CO_2-eq). Impact caused during brewing typically represents about 2 g CO_2-eq (for the soluble coffee) to 12 g CO_2-eq (for the less efficient full automat machine), while the contribution of the machine production ranges from 0.1 g CO_2-eq (for the soluble coffee) to 1 to 4 g CO_2-eq for the full automat or *Nespresso* machines. The impact of the water filter production and distribution for the full automat system is low (about 0.6 g CO_2-eq).

The use stage of *Nespresso* and full automat coffee systems lead to similar greenhouse gas emissions for the low intensity use (4 000 cups/year). For the more intense use (10 000 cups/year), the efficient full automat machine performs better than *Nespresso* while the less efficient full automat machine has a similar impact. The soluble coffee use stage has the lowest use stage impact among coffee systems assessed.

3.2.6 Overheads / Support

The Overheads/support stage contributes to 7% to 10% of the total greenhouse gas emissions (7 g CO_2-eq) and it was modelled using the same process for all coffee systems.
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.

3.2.7 End-of-life

The end-of-life of the *Nespresso* and full automat coffee systems greenhouse gas emissions ranging from 2 to 3 g CO_2-eq. The end-of-life for the soluble coffee system lead to a greenhouse gas emission benefit, with a score of -1 g CO_2-eq. This greenhouse gas emission benefit is mostly explained by the recycling of the glass jar for the soluble coffee.

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

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 the same as for the climate change: the green coffee supply and the use stage are the most important contributors, except for the water withdrawal and the land use for which the green coffee supply covers more than 80% of the impacts and the use stage has a smaller share.

For all indicators, the soluble coffee is the best-performing system, except for the non-renewable resources depletion, for which it has similar impacts to the *Nespresso* system with the Zenius machine. For all indicators, the *Nespresso* coffee systems are performing better than the full automat systems (efficient or non-efficient) for a same use intensity, except for the climate change and the non-renewable resources depletion for which the efficient full automat for the 10 000 cups scenario has similar impacts than the *Nespresso* system.

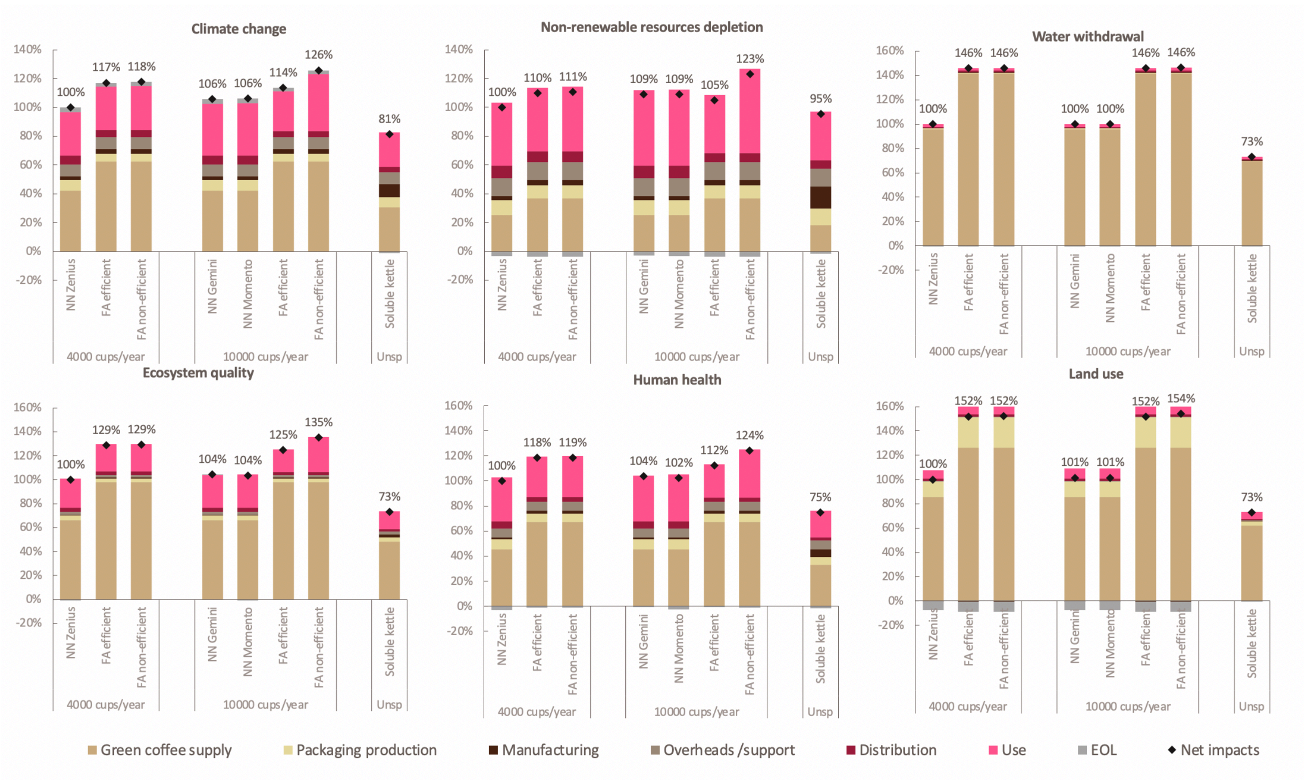


Figure 4: Life cycle stages contribution for the compared coffee systems for all impact indicators on the French market. For each indicator, all coffee systems were normalized with respect to the NN Zenius coffee system which impact was set at 100%.

3.4 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 cup), on the energy consumption for preparation (machine efficiency, amount of water boiled, etc.) or on the recycling rate of capsules (0-100%). Those analyses tend to show that none of the coffee system is intrinsically better than the other. A responsible consumer behavior for the full automat and the soluble systems could lead to similar or lower impacts than the *Nespresso* coffee system, while a non-responsible consumer behavior for the full automat and soluble systems will lead to higher impacts than *Nespresso*. The *Nespresso* system being more framed as a portioned system, its variability is much lower than the variability for the two other systems: portioned coffee system performances are much less dependent on consumer behavior than unportioned coffee systems.

A sensitivity analysis using the Swiss electricity mix for the entire life cycle was performed in the baseline study and it showed a reduction ranging from 10 to 20% of the carbon footprint of a cup of coffee.

In the framework of this adaptation, it was not meant to reassess all these sensitivity parameters. However, the effect of using the country specific electricity mix on the use stage was tested and showed a reduction ranging from 10 to 16 g CO_2-eq/cup on the use stage depending on the system as shown on the figure below.

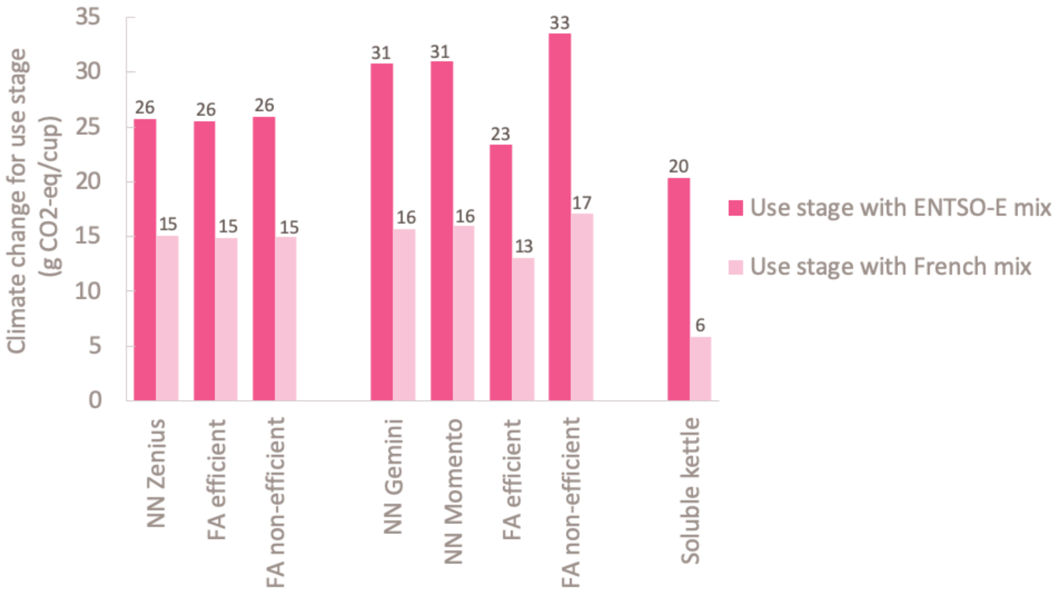


Figure 5: Influence of the electricity mix on the use stage for the coffee systems assessed: ENTSO-E mix is the average European mix used in the study, the French mix corresponds to the use of a country specific mix

Another element tested is the recycling rate of the Nespresso capsule: with a 100% recycling rate, the climate change score of the cup of espresso prepared from a Nespresso Pro capsule would be reduced by 6 g CO_2-eq, while with 0% recycling, it would increase of 2 g CO_2-eq.

4. Conclusion

The holistic view on the life cycle of the three different coffee preparation systems shows that drinking a 40 ml espresso cup of coffee made from a *Nespresso* coffee system in France has lower impact than the same cup of coffee made with full automat systems but higher impact than the same cup of coffee made with soluble coffee.
For the soluble coffee, its low amount of green coffee per cup and low electricity consumption for the use stage explain this good position.
The full automat coffee systems have the highest baseline impacts for all indicators assessed. This is particularly marked for the indicators that are mostly influenced by coffee supply. The differentiation between *Nespresso* and full automat scenario is mostly driven by the amount of green coffee needed per cup, even if the use stage of some of the full automat systems is more efficient than the *Nespresso* use stage.

A large part of the impact on the environment is rooted in the coffee preparation in the office (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. 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 or similar impact using a full automat or soluble coffee than the *Nespresso* Professional coffee system under specific conditions, but a less responsible person could prepare a higher impact cup of coffee using the full automat or soluble coffee systems compared with the *Nespresso* Professional. Thus, the *Nespresso* coffee system appears as a safeguard and stable solution against an environmental un-responsible use.

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. A sensitivity analysis considering local electricity mix for the use stage has been performed to see the influence of this hypothesis on the results. 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 systems and soluble coffee, 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 (climate change), 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 4 000 cups/year or 10 000 cups/year in a business environment, in France. 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:

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

- The *Nespresso* coffee system is modelled with 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 adaptation focuses on the French market and the detailed results observed are therefore true only for this specific market.
- Although the type of full automat machine considered correspond to most sold machines on the Swiss market, producers of these coffee machines are selling internationally and their coffee machines can commonly be encountered on the French market, it does not necessarily mean they are the most sold on the French market. As this report corresponds to an adaptation of the Swiss study to the French market, it was not meant to integrate new machines.
- 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. Indeed, it is accepted that all the coffee will be almost entirely degraded at end-of-life leading to a nearly neutral balance

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 French market 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 Lausanne office of Quantis. Please direct all questions regarding this report to Quantis Lausanne. www.quantis-intl.com

6. Data

Data considered to model Overheads, 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.
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 Organization 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.
NN	Nestlé Nespresso
OEF	Organization 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 the forming steps for primary, secondary and tertiary packaging. The primary packaging corresponds to the capsule for the *Nespresso* coffee system, a laminated pouch of 500 g roast and ground coffee for the full automat systems and a 242 g glass jar for the soluble coffee. The secondary packaging corresponds to the sleeve containing 50 capsules for the *Nespresso* and none for the full automat systems and soluble coffee. 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.