Comparative LCA assessment of

Fontinet filtered tap water
vs.
Natural sourced water in a PET bottle

FINAL REPORT
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Background

In the **context** of the sustainability ambition of the city of Lommel (Covenant of Mayors and first climate neutrale city in Flanders) the initiative is taken to promote the use of municipal tap water. Municipal tap water is suitable for drinking purposes (De Watergroep, Flanders). Belgians consume 124 liter and Dutchmen 18 liters (Koninklijke Verbond van de Industrie van Waters en Frisdranken, VIWF and water.nl) of bottled water per year per person. Because of the tap water taste and the perception of consumers that bottled water is more healthy (De Watergroep, water.nl), Prime Water launched the project to filter municipal tap water for household drinking purposes.

The project consists of:
1. Testing of the Fontinet filter by households in the area of Lommel
2. Functionality test by VITO (www.vito.be) comparing the Fontinet filter with other filtering systems
3. LCA study by Futureproofed comparing the Fontinet system and PET bottles.

Methodology

Life cycle assessment (LCA, also known as life-cycle analysis or cradle-to-grave analysis) is a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).

In this study, the ISO methodology will be applied[1]. The procedures of life cycle assessment (LCA) are part of the ISO 14000 environmental management standards: ISO 14040 and 14044 (2006).

According to the ISO 14040 and 14044 standards, a Life Cycle Assessment is carried out in four distinct phases as illustrated in the figure shown below. The phases are often interdependent: the results of one phase will inform how other phases are completed.

• **Goal and scope definition**: in the first phase of the LCA, the intended use (goal) and scope of the study have to be clearly defined. A functional unit has to be determined: this provides the reference to which the input and output data are allocated. Also, system boundaries must be precisely defined: which processes will be studied and in which detail, and which releases to the environment will be evaluated. Data quality requirements and assumptions will be determined.

• **Life Cycle Inventory Analysis**: this phase consists of the data collection and the definition of the calculations procedures. Data have to be collected for each process that is defined under the system boundaries, and will then be normalized accordingly to the functional unit.
As data is collected, new requirements or limitations may emerge. This can bring along extra data collection requirements or the redefinition of the system boundaries.

• **Life Cycle Impact Assessment**: in this phase the results of the inventory analysis are linked to environmental damage categories. It predicts potential environmental damages (impacts) related to the defined system.

• **Interpretation**: the impact assessment is analyzed and interpreted in line with the definition of the goal and scope. The interpretation can be done in the form of conclusions and recommendations.

[1] http://www.iso.org/iso/home/standards/management-standards/iso14000

Goal definition

1. Reasons for carrying out the LCA

The goal of this study is to compare the environmental impacts of water used by households for drinking purposes delivered by:

- municipal tap water filtered by a Fontinet system (www.fontinet.be) manufactured by Prime Water bvba of Lommel – Belgium

and

- natural sourced water from single use disposable PET bottles.

The focus will be on the identification of the hotspots in the environmental impact of both systems; in the different life cycle phases as well as in the environmental impact categories. A comparison between the results of both systems will be performed.

Unfiltered tap water will always have a lower environmental impact than filtered tap water. But because of the tap water taste and the perception of consumers that bottled water is more healthy (De Watergroep, water.nl), consumers revert to bottled water.
To offer an alternative to bottled water, Prime Water launched the project to filter municipal tap water for household drinking purposes.This Fontinet filter has the purpose to improves the water taste and filters out bacteria and particles larger than 0,15 micrometer, as well as residues of dissolved organic contaminants and lead.

2. Intended use of the results

In the context of the sustainability ambition of the city of Lommel (Convenant of Mayors and first climate neutral city in Flanders) the initiative was taken to promote the use of municipal tap water in conjunction with the Fontinet.

This project is financially supported by I-Cleantech Flanders. The project consists of:
- Testing of the Fontinet filter by households in the area of Lommel;
- Functionality test by VITO to validate the retention performance of the Fontinet filter;
- LCA study by Futureproofed comparing the Fontinet system and PET bottles.

It is the purpose of Prime Water to use the outcome of this LCA for Fontinet product communication to households on European markets, the potential clients of PrimeWater.

For this reason, the ISO methodology (as described in the previous chapter) will be applied. The study will be reviewed by an external expert[2], accordingly to the ISO 14040 and 14044 guidelines.

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[2] VITO (Vlaamse Instelling voor Technologisch Onderzoek), Boerentang 200, 2400 Mol. www.vito.be

Scope definition

1. Product systems and functions

• **Fontinet filter system**
The Fontinet filter unit is either placed between the cold water inlet and filtered water faucet underneath the kitchen sink or placed on top of the counter and connected with the faucet. In this case consumers can turn a valve to switch between filtered water or unfiltered water (www.fontinet.be).

The Fontinet filter system consists of the Fontinet filter (activated carbon, membrane micro-filter), the filter housing and furthermore the municipal tap water production and distribution system.
The Fontinet filter consists of two parts:
- activated carbon for the improvement of the taste and the removal of residues of dissolved chemicals, pesticides, lead and medicines.
- a membrane micro-filter that removes all bacteria and particles > 0.15 uM (= 0.00015 mm).

The water filter first flows through the activated carbon shell and then exits through the membrane micro-filter filter.

Figure 1: Fontinet filter system

• **PET bottled water system**
PET bottles are used to pack and transport natural sourced drinking water to the customer. The PET bottled water system consists of the PET bottles, the natural sourced water, filling and distribution of the bottles.

2. Functional Unit

The functional unit is the making available of 1,5 liter filtered tap water or 1,5 liter natural sourced water, for household **drinking purposes**.
This volume corresponds with the volume of the commonly known single use disposable PET bottles for natural sourced drinking water. The main purpose of the functional unit is to compare the impact of Fontinet filtered water with PET bottled water.

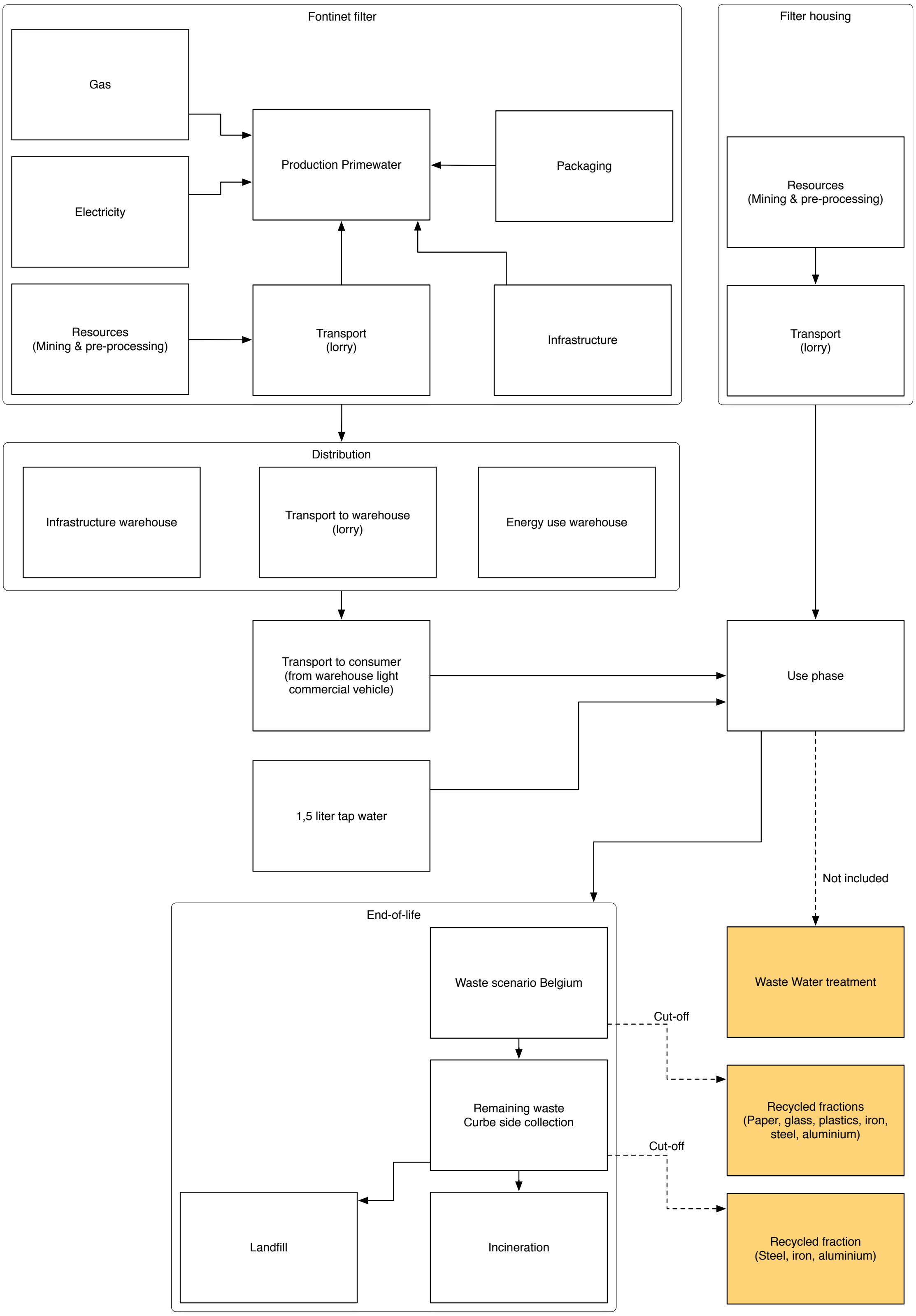
3. System boundaries

In this LCA we are taking into account:
- The extraction and distribution of municipal tap water and natural sourced water, infrastructure included. Reversed osmose (RO water) is excluded, since this method of water treatment is not relevant for the European markets.
- The life cycle of one Fontinet filter system and a PET bottle from the production of raw materials up to the end-of life of the filter and the bottle. The material production phase includes the extraction of the raw materials as well as the material manufacture and assembling. We include infrastructure and the transportation of the product to the customer.

- The use phase (cooling of water) and recipient cleaning (drinking cup) are excluded. We assume them to be equal for both LCA's. Also, cooling by retailers is excluded.
- Use of packaging.
- Any disposal or recycling of waste from intermediate stages (waste products of extraction and manufacture, or packaging waste) that has a significant impact is included.

All inputs and outputs to a (unit) process shall be included in the calculation, for which data are available. Data gaps may be filled by conservative assumptions with average or generic data. Any assumptions for such choices shall be documented; In case of insufficient input data or data gaps for a unit process, materials and processes can be omitted, if the process contributes with less than 1% of mass or renewable or non-renewable primary energy of the total, and all excluded materials and processes do not exceed 5% of total energy use and mass.

Figure 2 and 3 represent the process tree for both product life cycles.
Figure 4 displays a graphical representation of the end-of-life scenario.



Figures 2: Process tree life cycle 1,5 liter Fontinet water

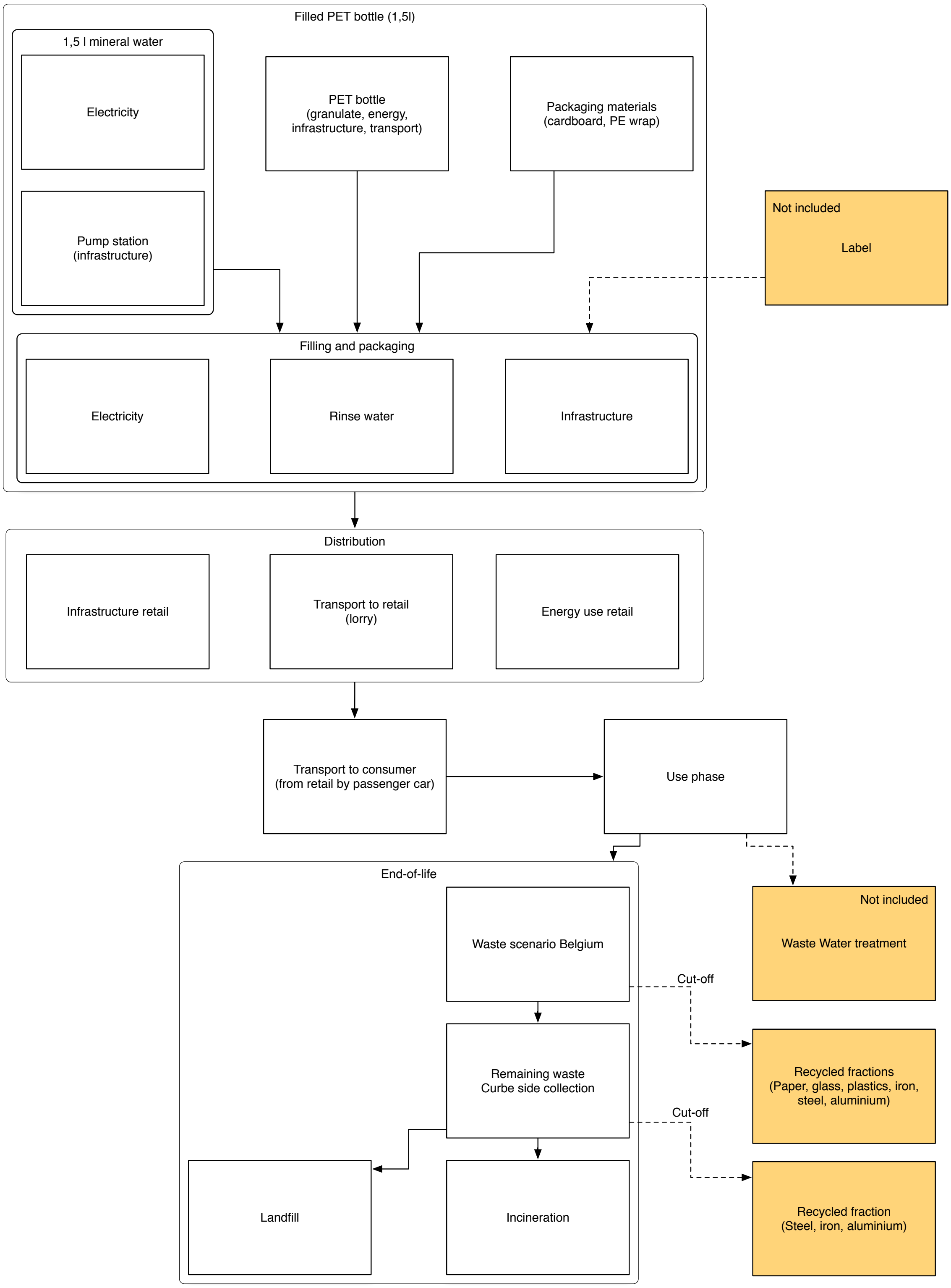


Figure 3: Process tree life cycle 1,5 liter natural sourced water in PET bottle

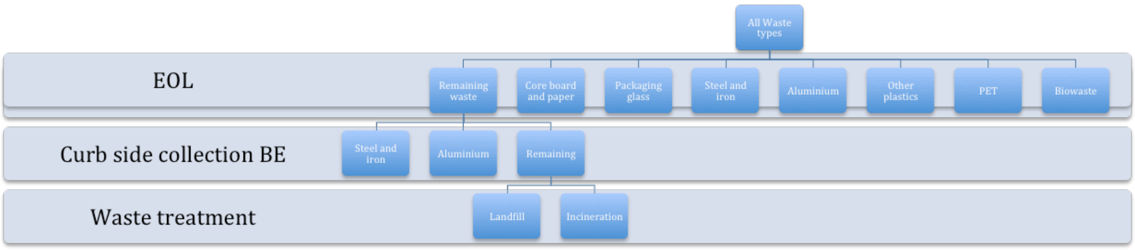


Figure 4: Graphical representation of the end-of-life scenario

4. Allocation procedures

• **Fontinet filter**
In order to allocate the impact of the life cycle of the Fontinet filter to 1,5 liter filtered tap water, certain assumptions have to be made. The filter itself is suited to filter 4.000 liters, before it becomes saturated. The producer recommends to replace the filter annually, regardless of the amount of water filtered.

Since our functional unit is to make available 1,5 liter of **drinking water** to the household consumer, we can not allocate the impact of the filter to other types of use. We would have to take the perspective on how much liters of natural sourced water it could replace.

On average in Belgium, one person consumes 124 liter of bottled water per year (data: 2011). This is 285,2 liter of drinking water per household per year. This means that we can make the assumption that one filter, if you have to replace it annually, will have produced 285,2 liter of drinking water. This is of course an average. One could assume that households who do not consume tap water at all for drinking purposes, will consume more natural sourced water than the average.

Because of the high variance in the amounts of drinking water that will be consumed and filtered per year, we suggest to work with a sensitivity analysis. Our **basic scenario** is that one filter, if replaced annually, will have produced **500 liter** drinking water. The entire life cycle of the Fontinet filter will also be rerun with the annual household consumption of 250 liter and again with the annual household consumption of 750 liter.

The entire impact of the filter will be allocated on this amount of drinking water.

All other allocation procedures (transport, infrastructure,...) throughout the project will be commented on in the report (see Life Cycle Inventory).

• **End-of-life PET**
In this study we will apply the end-of-life recycling approach for PET bottles. The impacts of recycling and the avoided burdens of the production of virgin material are taken into account at the end of the life cycle.

5. Impact assessment methodology

SimaPro 8 software, the most widely spread LCA software, was used for this study. The impact assessment methodology chosen is the ReCiPe methodology.

The main aim of the ReCiPe method is to convert the long list of inventory results into a limited number of indicator scores. These scores indicate the relative seriousness of each environmental impact category. In ReCiPe, indicators are distinguished at three levels:
1. Eighteen **midpoint** indicators
2. Three **endpoint** indicators
3. A **single score** indicator

The 'problem oriented approach' defines the impact categories at a midpoint level.[3] The uncertainty of the results at this point is relatively low. The drawback of this solution is that it leads to many different impact categories which makes the drawing of conclusions with the obtained results complex. The damage oriented approach results in only three impact categories, which makes the interpretation of the results easier. However, the uncertainty in the results is higher. ReCiPe implements both strategies and has both midpoint (problem oriented) and endpoint (damage oriented) impact categories. The midpoint characterisation factors are multiplied by damage factors, to obtain the endpoint characterisation values. ReCiPe comprises two sets of impact categories with associated sets of characterisation factors. At the midpoint level, 18 impact categories are addressed:

- Ozone depletion
- Human toxicity
- Ionizing radiation
- Photochemical oxidant formation
- Particulate matter formation
- Terrestrial acidification
- Climate change
- Terrestrial ecotoxicity
- Agricultural land occupation
- Urban land occupation
- Natural land transformation
- Marine ecotoxicity
- Marine eutrophication
- Fresh water eutrophication
- Fresh water ecotoxicity
- Fossil fuel depletion
- Minerals depletion
- Fresh water depletion

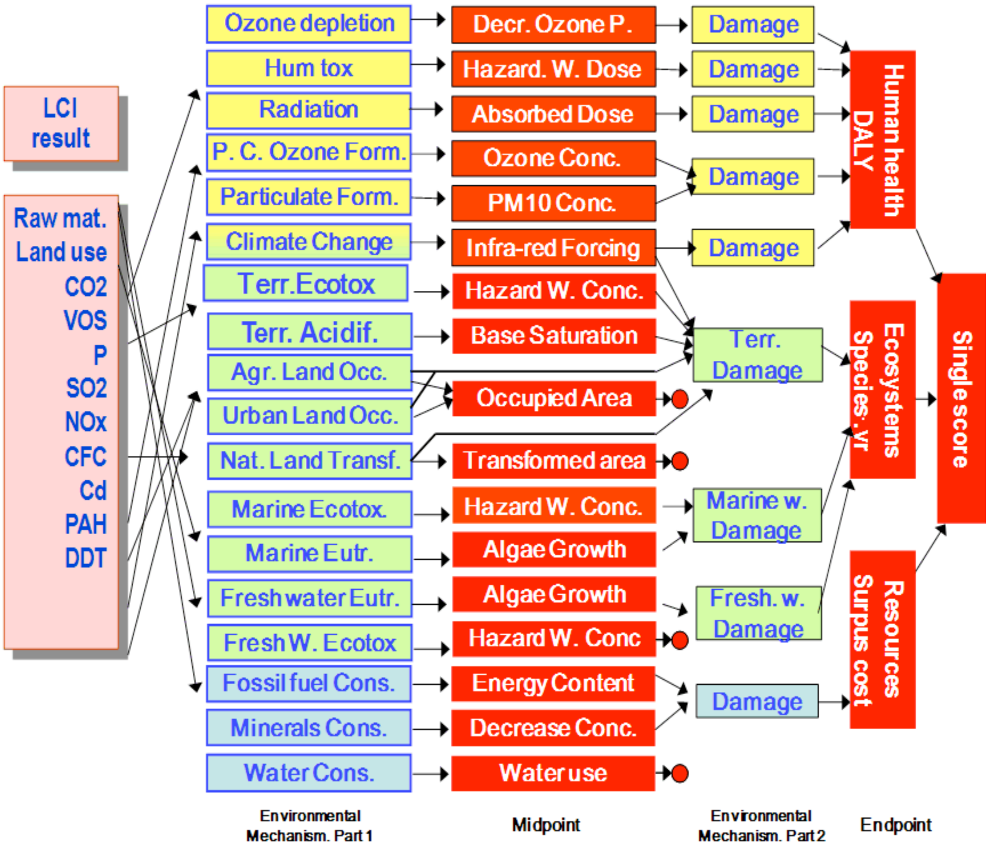
At the endpoint level, most of these midpoint impact categories are multiplied by damage factors and aggregated into three endpoint categories[4]:

- Human health
- Ecosystems
- Resource surplus costs

The three endpoint categories are normalized, weighted, and aggregated into a single score.

[3] Handbook on Life Cycle Assessment - Operational Guide to the ISO Standards - Jeroen B. Guinée (Ed.) 2002

[4] SimaPro Database Manual Methods library - PRé Consultants 2010



The idea is that each user can choose the level at which they wish to have their results: eighteen relatively robust midpoints that are hard to interpret, though, or three easy to understand but more uncertain endpoints.

The unit of the scores is in Eco-indicator points (Pt). These are numbers that express the total environmental load of products during the life cycle. The absolute value of the points is not relevant, since the main goal of the scoring is to compare relative differences between products, process or components. The scale of the value is as followed: 1 Pt represents one thousandth of the yearly environmental load of one average European inhabitant.

It is obvious that the environmental mechanisms and damage models are sources of uncertainty: the relationships modelled reflect state of the art knowledge of the environmental mechanisms that has a certain level of incompleteness and uncertainty. In ReCiPe it was decided to group different sources of uncertainty and different (value) choices into a limited number of perspectives or scenarios, according to the “Cultural Theory” by Thompson 1990. Three perspectives are discerned: individualist (I), hierarchist (H), and egalitarian (E).

Perspective H is based on the most common policy principles with regards to time-frame and other issues. It is the chosen approach for this study.

4. Data requirements

SimaPro 8 software was used to model the life cycles. The data for the products examined was collected in 2013 and provided by the customer or was taken form the Ecoinvent 3 database with focus on the average European production. For sub flows that are related to consumption in Belgium these data sources are generally representative. When there is a choice of several processes and there are no or just small arguments for one of the processes, then the use of Ecoinvent has an advantage because of the systematic approach and thus because mistakes are avoided when the processes are compared (because different background data might be used).

All data was checked for plausibility and consistency.

5. Assumptions

All assumptions made during the execution of this LCA will be clearly described in the final report (see Life Cycle Inventory).

Life cycle Inventory

1. Fontinet filtered tap water

- All data relevant for the life cycle of the Fontinet filter and filter housing are data specific from Primewater.
- The quantities of the materials in the table below are quantities required for the production of one Fontinet filter (1 year or lifespan 4.000 liter drinking water; after this volume it is saturated and has to be replaced) and the plastic housing (lifespan 10 years, assumption Primewater). In the impact assessment we will allocate the impact of the filter and the housing to 1,5 liter drinking water (functional unit).

Process / material	Quantity	Data record	Source	Comment
Tap water	1,5 kg	Tap water at user (Europe without Switzerland) / Tap water production and supply	Ecoinvent v3	Infrastructure and energy use for water treatment and transportation to end user. No emissions from water treatment.
N-methyl-2-pyrrolidone	0,0334 kg	N-methyl-2-pyrrolidone, (RER) / production	Ecoinvent v3	
+ Incoming transport	*0,00735 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 220 km 0,0334 kg*220 km/1000*
Polyether-sulfone	0,0067 kg	Polycarbonate (RER) / production	Ecoinvent v3	Use of polycarbonate as proxy "PES is a tough and rigid resin similar to conventional engineering plastics, such as polycarbonate, molded on common injection-molding equipment." Source: Polyethersulfone (PES) Technical Literature Mitsui Chemicals, Inc.
+ Incoming transport	*0,000503 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 75 km 0,0067 kg*75 km/1000*
Polyvinyl-pyrrolidone	0,0038 kg	N-methyl-2-pyrrolidone, (RER) / production	Ecoinvent v3	Use of N-methyl-2-pyrrolidone as proxy. Can be changed during sensitivity analysis, but weight is relatively small.
+ Incoming transport	*0,00144 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 378 km 0,0038 kg*378 km/1000*
Glycerine	0,003 kg	Glycerine (EU), esterification of rape oil	Ecoinvent v3	Supplier glycerine (Ceepal - Overpelt) does not release information on specific raw material for glycerine, except that it is vegetal based and palm oil is excluded. Chosen record (assumption Futureproofed): rape oil based glycerine
+ Incoming transport	*2,7E-5 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 9 km 0,003 kg*9 km/1000*
Water	4,4058 kg	Water, deioinised, from tap water, at user (GLO) / market for	Ecoinvent v3	No data on incoming transport available; 'market for' record chosen

Process / material	Quan tity	Data record	Source	Comment
Natrium-hypochlorite	0,0027 kg	Sodium hypochlorite, without water, in 15% solution state (RER)	Ecoinvent v3	Available proxy for 14% solution (as stated by client)
+ Incoming transport	*2,43E-05 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 9 km 0,0027 kg*9 km/1000*
MF 8 tube	0,0227 kg	Polystyrene, high impact (RER) / production	Ecoinvent v3	Polystyrene
	0,0227 kg	Extrusion, plastic pipes (RER) / production	Ecoinvent v3	Extrusion
+ Incoming transport	*0,00431 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 190 km 0,0227 kg*190 km/1000*
"Kraagpakking"	0,0001 kg	Polyethylene, low density, granulate (RER) / production	Ecoinvent v3	Thermoplast, composition: source Futureproofed and Ecoinvent 3: 1,34% polyethylene 50,6% polypropylene 48,06% polystyrene
	0,0044 kg	Polypropylene, granulate (RER) / production	Ecoinvent v3	Composition thermoplast, source Futureproofed and Ecoinvent 3
	0,0042 kg	Polystyrene, high impact (RER) / production	Ecoinvent v3	Composition thermoplast, source Futureproofed and Ecoinvent 3
+ Incoming transport	*0,00167 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 190 km 0,0088 kg*190 km/1000*
Activated carbon	0,38 kg	Hard coal (ROW), market for	Ecoinvent v3	Activated carbon, transport included (record chosen: market for)
	0,38 kg	Heat (natural gas), Electricty and water	Ecoinvent v3	Production process for activated carbon filter composed by Futureproofed, source: A LCA Study of Activated Carbon Adsorption and Incineration in Air Pollution Control - University of Borås
"Eindkap"	0,015 kg	Acrylonitrile-butadiene-styrene copolymer (RER) production	Ecoinvent v3	ABS
+ Incoming transport	*0,00285 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 190 km 0,015 kg*190 km/1000*
Seal	0,0067 kg	Synthetic rubber (RER) production	Ecoinvent v3	Synthetic rubber
+ Incoming transport	*0,00127 tkm*	*Transport, freight, lorry, unspecified (GLO) / market for*	*Ecoinvent v3*	*Data provided by PrimeWater: distance 190 km 0,0067 kg*190 km/1000*
Blow moulding ("kraagpakking", seal, "eindkap")	0,0305 kg	Blow moulding, (GLO) market for	Ecoinvent v3	Blow moulding of different parts of cartridge ("kraagpakking", "eindkap", seal)

Process / material	Quan tity	Data record	Source	Comment
ABS housing	1 kg	Acrylonitrile-butadiene-styrene copolymer (RER) market for	Ecoinvent v3	Purchased separately from filter: Primewater does not supply this. Record chosen: ‘market for’, no data for transport available Allocation: lifespan 10 years (assumption Primewater)
	1 kg	Blow moulding, (GLO) market for	Ecoinvent v3	Blow moulding of ABS filter housing
Connector	0,11 kg	Steel, low-alloyed (GLO) / market for	Ecoinvent v3	Purchased separately from filter: Primewater does not supply this. Record chosen: ‘market for’, no data for transport available Allocation: lifespan 10 years (assumption Primewater)
	0,11 kg	Metal working, average for steel product manufacturing (GLO)	Ecoinvent v3	Average for steel product manufacturing
Electricity	1,02 kWh / unit	Electricity, low voltage, at grid BE	Ecoinvent v3	0,051 €/ assembly 1 unit, all in (Primewater) 0,050 € / kWh: current industry prices (Futureproofed)
Gas	0,04 kWh / unit	Natural gas, burned in boiler condensating modulating < 100kW, RER	Ecoinvent v3	0,006 €/unit assembly 1 unit, all in (Primewater) 0,15 € / kWh: current industry prices (Futureproofed)
Infrastructure	1E-7 m	Building hall, steel construction	Ecoinvent v3	Production hall Primewater: 500m Production capacity PrimeWater: 300.000 pcs / year Assumption FP: lifespan building: 50 years (source: Ecoinvent Lifetime infrastructure) Allocation for functional unit 1,5 liter: 1,5 liter* 500m capacity per year / 500 liter year (drinkrate) = 1E-7m
Packaging	0,0001 25 kg	Folding boxboard/ chipboard (GLO) / market for	Ecoinvent v3	Data PrimeWater: 1 box for 24 units 1 box for 24 units weighs +/- 1 kg (Source Valipac: size: 50 x 50 x 30 cm) Allocation for functional unit 1,5 liter: 1,5 liter*1/24/ 500 liter year (drinkrate) = 0,000125 kg
Distribution	0,0002 15 tkm	Transport, freight, lorry, unspecified (GLO) / market for	Ecoinvent v3	First assumption Futureproofed for European market: 500 km distribution range to central warehouse. No data readily available at client. System variant for analysis. Allocation: 1,5 liter*weight filter*500km / 1000 / 500 liter per year (drinkrate)
	0,0002 29 m2	Building hall, steel construction	Ecoinvent v3	Warehouse infrastructure. Allocation: same surface as retail infrastructure (economical allocation by Futureproofed: m 4,95E-6, see table PET bottle). 69,5€: price Fontinet filter 1,5€: average price 1,5liter natural sourced water in PET bottle 4,95E-6 * 69,5 / 1,5 = 0,00029 m Sources: De Belgische voedingsmarkt 2010-2011 | Retail Detail, andhttp://statbel.fgov.be/nl/statistieken/cijfers/ economie/kleinhandel/voeding/

Process / material	Quan tity	Data record	Source	Comment
	0,5kg	Retail, short time storage, room temp, large store	LCA Food DK	0,5kg = weight filter Heat and electricity warehouse
Transport to client	2,32E-5 tkm	Transport, freight, light commercial vehicle (GLO) / market for	Ecoinvent v3	Filters will be delivered from the central warehouse to consumers with post delivery services. No data readily available at client. Assumption Futureproofed: 16 kilometer distance warehouse to consumer. Allocation: 1,5liter*weight filter*16km / 1000 / 500 liter per year (drinkrate)
End-of-life		Waste scenario (BE) / treatment of waste	Ecoinvent v3	Fontinet filter: to household waste every 500 liter (liter year). Filter housing: to household waste every 10 years (assumption Primewater) Waste scenario BE composed by Futureproofed (variant on NL scenario): - Recycling rates for BE context added (source: Fostplus 2012) - Curb side collection; for waste not recycled (incineration / landfill) (source: Eurostat 2011)

2. PET bottled water

- Data in the table below are already allocated to 1,5 liter of drinking water.
- Data on the production of natural sourced water (pumping, storage, treatment, infrastructure) seem, after a first desk research, not publicly available for the European market. Data are derived from a study by the University of Michigan: 'Comparative Life-Cycle Assessment of bottled vs. Tap water systems'[5].

Process / material	Quantity	Data record	Source	Comment
Natural sourced water treatment	0,0046 kWh / 1,5 kg	Electricity, low voltage, at grid BE	Ecoinvent v3	UV filtration: 0,17 kWh / 1000 gallon Water softener: 0,17 kWh / 1000 gallon UV treatment: 1,01 kWh / 1000 gallon Ozone system: 10,26 kWh / 1000 gallon total: 11,61 kWh / 1000 gallons (Dettore C., Comparative Life-Cycle Assessment of bottled vs. Tap water systems' p.93) 1 gallon = 3,79 liter
	2,0568E-11	Pump station, water storage / CH	Ecoinvent v3	Materials, transport, disposal for infrastructure, for 1,5 liter water.
PET bottle	0,035kg	Polyethylene terephthalate, granulate, bottle grade (GLO), market for	Ecoinvent v3	http://www.federplast.be, weight average PET bottle: 35g
	2,59E-11 p	Plastic processing factory (RER) construction	Ecoinvent v3	Production capacity: 27.000 ton / year (Source: Ecoinvent) Assumption FP: lifespan building: 50 years (source: Ecoinvent Lifetime infrastructure) 0,035/1000/27000/50 = 2,59E-11 p
	0,035kg	Blow moulding, (GLO) market for	Ecoinvent v3	Blow moulding of PET bottle
	0,00875 tkm	Transport, freight, lorry, unspecified (GLO) / market for	Ecoinvent v3	Transport to bottling facility, assumption Futureproofed: 250km 0,035*250/1000 = 0,00875 tkm
Label				Labels, ink and glue are assumed to be less than 1% of the system and are thus excluded from this study (Dettore C., Comparative Life-Cycle Assessment of bottled vs. Tap water systems)
Filling and packaging	0,0172 kWh / 1,5 kg water	Electricity, low voltage, at grid BE	Ecoinvent v3	43,57 kWh / 1000 gallons (Dettore C., Comparative Life-Cycle Assessment of bottled vs. Tap water systems p.93)
	0,1 liter water	Tap water at user (Europe without Switzerland) / Tap water production and supply	Ecoinvent v3	Rinse water: 6,72% of fill water (Dettore C., Comparative Life-Cycle Assessment of bottled vs. Tap water systems p.93)
	0,014g	Packaging film, LDPE (GLO) / market for	Ecoinvent v3	Polyethylene wrap around 6-pack 1,5l bottles, source: Futureproofed

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[5] Dettore, C. Comparative Life-Cycle Assessment of Bottled vs. Tap Water Systems. Center for Sustainable Systems, University of Michigan, 2009

Process / material	Quantity	Data record	Source	Comment
	0,0041 kg	Corrugated cardboard (GLO) / market for	Ecoinvent v3	Source: Tap water vs. Bottled water in a Footprint Integrated approach - Department of Environmental Sciences, University of Siena
	6,62E-6 m	Building, hall, steel construction	Ecoinvent v3	Assumption made, source: Topbronnen-Inexco site. Buildings: 30.000 m Yearly production: 136.000.000 liter, Life time building: 50 years 1,5l*30.000m
Distribution	0,227 tkm	Transport, freight, lorry, unspecified (GLO) / market for	Ecoinvent v3	First assumption Futureproofed for European market: 500 km distribution range. No market data readily available. System variant for analysis. Allocation: 1,535kg*500 km/1000
Retail	1,5 kg	Retail (short time storage, room temp., large store)	LCA Food DK	Heat and electricity supermarket
	4,95E-6 m	Building hall, steel construction	Ecoinvent v3	Allocation: economical Turnover supermarkets / total m versus price 1 bottle Source:De Belgische voedingsmarkt 2010-2011 http://statbel.fgov.be/nl/statistieken/cijfers/economie/kleinhandel/voeding/
Transport to client	0,53 km (round trip)	Transport, passenger car / RER	Ecoinvent 3	Distance: Assumption Futureproofed - source data: carbon footprint assessment Belgian retailer: 16 km Allocation: Assumption Futureproofed: one bottle 1,5l water one of thirty items purchased (3,33% of burden transport)
End-of-life		Waste scenario (BE) / treatment of waste		Waste scenario BE composed by Futureproofed (variant on NL scenario): - Recycling rates for BE context added (source: Fostplus 2012) - Recycling rate for PET in Belgium: 71% (Fostplus 2012) - Curb side collection; for waste not recycled (incineration / landfill) (source: Eurostat 2011)

Life cycle impact assessment

1. Intro

During impact assessment, the emission- and consumption-data of the inventory phase are aggregated and converted into a contribution to environmental impact categories. The result of the impact assessment is a figure or table in which the environmental themes (environmental impact categories) are presented. For this project Futureproofed uses the different life cycle impact categories as defined by the ReCiPe method. Futureproofed applies the LCA software package “SimaPro 8.0.1” for performing the life cycle impact assessment (LCIA) and generating the environmental profiles.

In discussing the results of the individual profile of the Fontinet filtered water and PET bottled natural sourced water (expressed per functional unit) it is important to know whether or not a process has a significant contribution to an environmental impact category. For that the ISO framework (ISO 14044 - Annex B) is used. According to the ISO 14044 Annex B the importance of contributions can be classified in terms of percentage.

The ranking criteria are:

- A: contribution > 50 %: most important, significant influence;
- B: 25 % < contribution ≤ 50 %: very important, relevant influence;
- C: 10 % < contribution ≤ 25 %: fairly important, some influence;
- D: 2,5 % < contribution ≤ 10 %: little important, minor influence;
- E: contribution < 2,5 %: not important, negligible influence.

The next paragraphs present and discuss the environmental profile of the Fontinet filtered water resp. PET bottled natural sourced water. At the end of this chapter sensitivity analyses are presented that discuss the influence of some parameters on the environmental profile.

2. Fontinet filtered tap water: environmental profile

Table 1 and figure 5 show the environmental profile of the life cycle of 1,5 liter filtered Fontinet water in absolute figures. It shows the environmental impact per life cycle phase, per impact category. For each impact category, the impact is defined at 100%, so the relative impact of each life cycle phase is represented.

For those phases that result in an environmental credit (due to avoided material production in case of recycling or avoided energy production in case of incineration with energy recovery), this credit is presented as a negative impact in proportion to the total environmental impact.

The environmental profile is calculated in ReCiPe midpoints.

Impact category	Unit	Total	1,5 liter tap water	Fontinet filter	Filter housing	Distri-bution	Transport to consumer	End-of-life
Climate change	kg CO	0,016261	0,000535	0,006408	0,001943	0,000340	0,000045	0,006991
Ozone depletion	m^3	6,15E-10	4,15E-11	4,37E-10	4,12E-11	2,00E-11	3,06E-12	7,20E-11
Terrestrial acidification	kg oil eq	4,11E-05	2,31E-06	2,43E-05	7,14E-06	2,36E-06	1,88E-07	4,83E-06
Freshwater eutrophication	kg Fe eq	6,21E-06	2,94E-07	4,91E-06	3,61E-07	7,46E-08	8,57E-09	5,60E-07
Marine eutrophication	kBq U235 eq	4,86E-06	1,28E-07	2,32E-06	3,67E-07	1,03E-07	9,65E-09	1,92E-06
Human toxicity	kg 1,4-DB eq	0,000610	6,70E-05	0,000259	6,10E-05	3,93E-05	4,68E-06	0,000178
Photochemical oxidant formation	m^2a	3,3E-05	1,59E-06	1,52E-05	6,15E-06	2,07E-06	2,80E-07	7,73E-06
Particulate matter formation	kg NMVOC	1,47E-05	9,33E-07	7,93E-06	2,82E-06	9,78E-07	9,07E-08	1,97E-06
Terrestrial ecotoxicity	kg SO2 eq	1,35E-06	1,23E-07	9,92E-07	6,04E-08	3,34E-08	4,93E-09	1,33E-07
Freshwater ecotoxicity	m^2a	1,26E-05	2,90E-06	8,76E-07	7,77E-07	5,12E-07	6,66E-09	7,54E-06
Marine ecotoxicity	kg 1,4-DB eq	9,42E-06	8,80E-07	4,21E-06	1,10E-06	5,26E-07	8,73E-08	2,62E-06
Ionising radiation	kg PM10 eq	0,003280	0,000209	0,002869	0,000137	0,000023	0,000004	0,000038
Agricultural land occupation	m^2	0,001157	3,45E-05	0,000746	0,000410	1,19E-05	4,88E-07	-4,62E-05
Urban land occupation	kg 1,4-DB eq	0,000164	0,000024	0,000102	0,000012	0,000011	0,000001	0,000014
Natural land transformation	kg P eq	1,51E-06	1,73E-07	1,25E-06	1,15E-07	5,96E-08	1,25E-08	-9,88E-08
Water depletion	kg N eq	0,053053	0,002852	0,045600	0,002968	0,000626	0,000057	0,000950
Metal depletion	kg 1,4-DB eq	0,000522	0,000039	0,000234	0,000141	5,571E-05	4,88E-06	4,72E-05
Fossil depletion	kg CFC-11 eq	0,004717	0,000133	0,003674	0,000791	9,41E-05	1,52E-05	9,62E-06

Table 1: Absolute figures of the environmental profile of 1,5 liter filtered Fontinet water, characterisation, midpoint.
For more details about what is included in each phase, please refer to Figure 2.

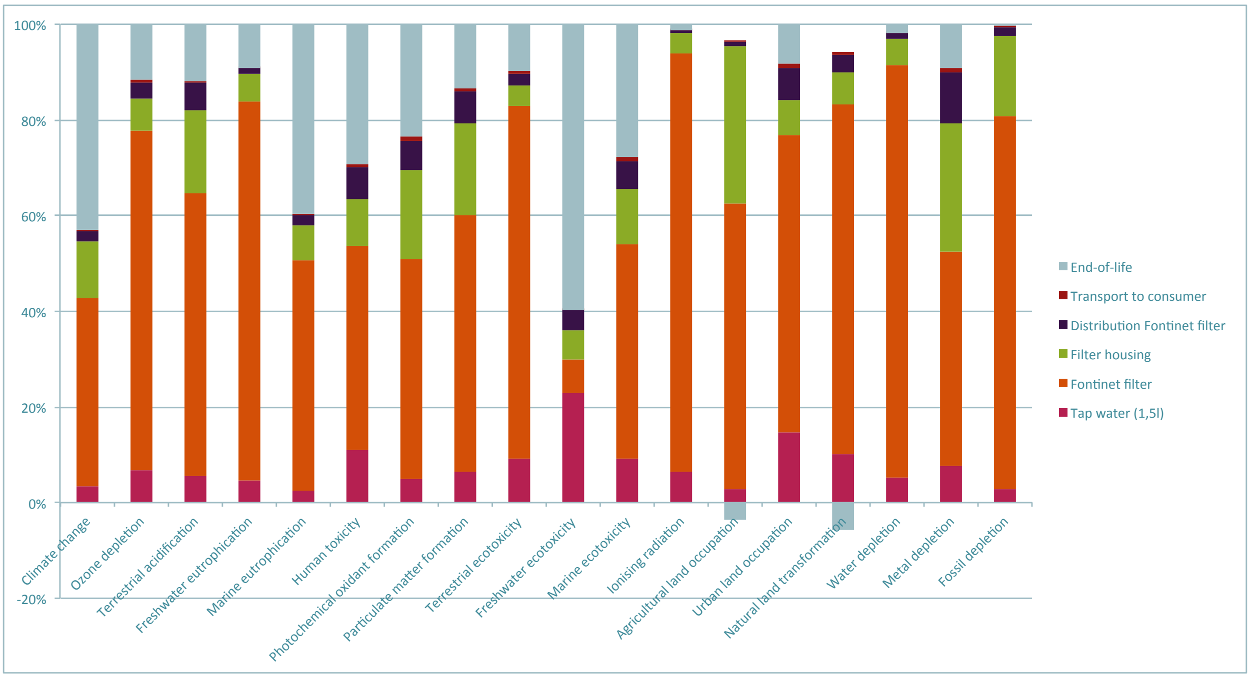

Figure 5: Environmental profile of 1,5 liter filtered Fontinet water, characterisation, midpoint
For more details about what is included in each phase, please refer to Figure 2.

The production of the Fontinet filter is the most important in all environmental impact categories, except in categories climate change and freshwater ecotoxicity. In the impact category climate change the production of the Fontinet filter stays very important and in the impact category freshwater ecotoxicity it becomes little important.
The **end-of-life** phase is the most important in freshwater ecotoxicity and very important in climate change.
The production of the **filter housing** (material: ABS & steel) has a relevant influence on the categories agricultural land occupation and metal depletion.
The production of 1,5 liter tap water has a relevant influence to the category freshwater ecotoxicity.

Normalization

Normalization is the analysis of the magnitude of the category indicator results relative to a chosen reference information dataset, in this case the annual environmental profile of an average European.

Figure 6 presents the normalized environmental profile for 1,5 liter filtered Fontinet water. For the following environmental impact categories the contribution caused by the life cycle of 1,5 liter filtered Fontinet water is relevant compared to the contribution made by economic activity in Europe:

- Freshwater eutrophication;
- Natural land transformation;
- Fossil depletion.

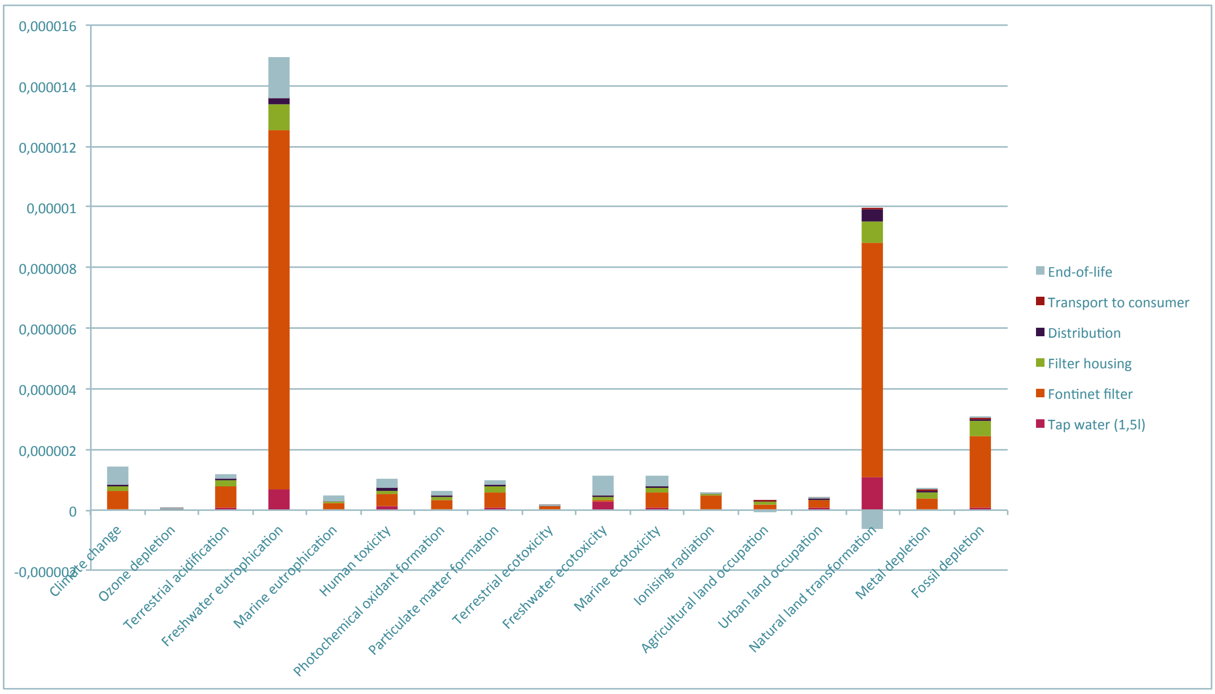

Figure 6: Normalized environmental profile of 1,5 liter filtered Fontinet water, midpoint
For more details about what is included in each phase, please refer to Figure 2.

These 3, most important environmental impact categories are discussed below separately:

Freshwater eutrophication

Figure 7 shows the relative importance of the different phases of the life cycle of 1,5l Fontinet filtered tap water within the impact category freshwater eutrophication.

- The impact of the **production of the Fontinet filter** is most important in this category (79%). It is mainly related to the emissions of phosphate to water due to spoil from hard coal mining, related to the production of the **activated carbon** for the filter. This is a worst case representation as most activated carbon consists of a mix of different carbons, such as coal, charcoal and carbonized coconut shells. The composition of this mix is proprietary.
-End-of-life (9%), minor influence: the impact on freshwater eutrophication is mainly related to the incineration of municipal waste.

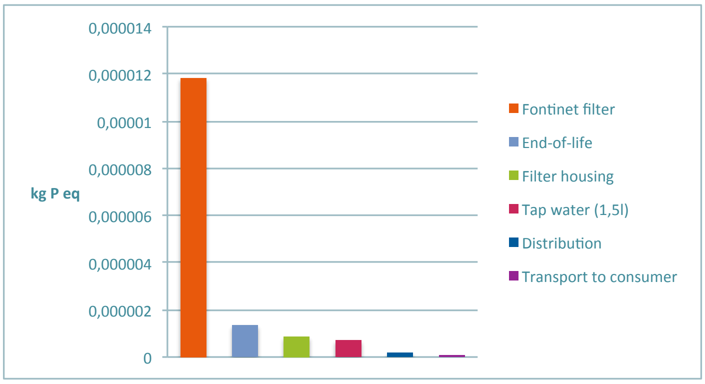

Figure 7: Environmental profile of 1,5 liter filtered Fontinet water, impact category 'freshwater eutrophication'
For more details about what is included in each phase, please refer to Figure 2.

- Filter housing (6%), minor influence: the impact of the filter housing in this category is caused by the energy required (spoil from mining for electricity) for the blow moulding of the ABS for the filter housing.
- Tap water production and supply (5%), minor influence: the impact is mainly related to the spoil from lignite mining, due to the electricity needed for the production and supply of tap water.
- Distribution and transport to the consumer is negligible to this impact category (<1,5%).

Natural land transformation

Figure 8 shows the relative importance of the different phases of the life cycle of 1,5l Fontinet filtered tap water within the impact category natural land transformation.

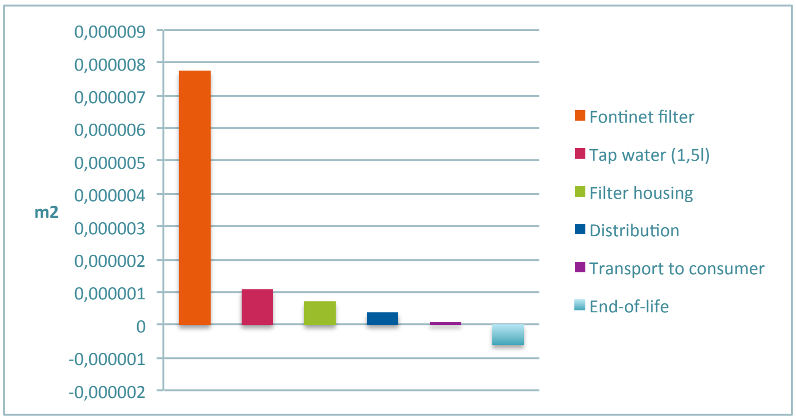

Figure 8: Environmental profile of 1,5 liter filtered Fontinet water, impact category 'natural land transformation'
For more details about what is included in each phase, please refer to Figure 2.

- The impact of the Fontinet filter is again most important (83%), again mainly related to the production of the **activated carbon** of the filter (mining for the hard coal, and in a lesser extent, the use of natural gas for the production process of the coal).
- Tap water production and supply (11%), some influence: the impact related to natural land transformation is caused by the infrastructure for production and supply of tap water.
- Filter housing (8%), minor influence: the impact on natural land transformation is related to the blow moulding process for the production of the ABS filter housing. It is caused by the heavy fuel and the wood required for the process.
- End-of-life (-6%), minor influence: the negative impact on natural land transformation is generated by the standard recycling of different materials used during the life cycle of the filter.
- Distribution and transport to consumer (<5%), minor influence.

Fossil depletion

Figure 9 shows the relative importance of the different phases of the life cycle of 1,5l Fontinet filtered tap water within the impact category fossil depletion.

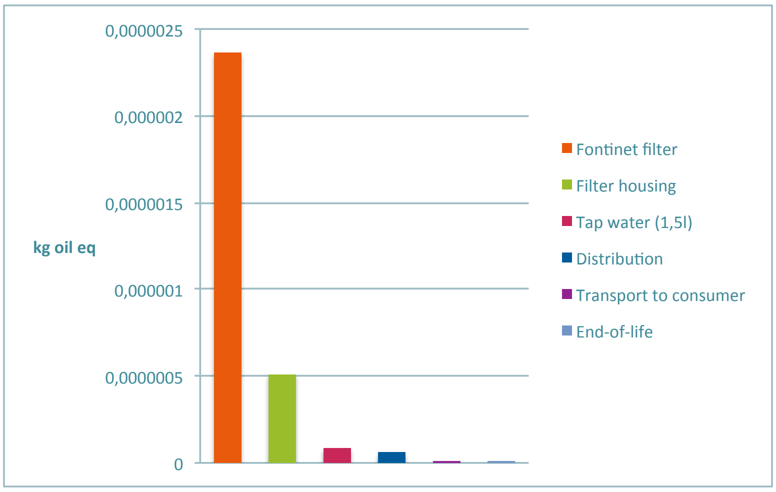

Figure 9: Environmental profile of 1,5 liter filtered Fontinet water, impact category 'fossil depletion'
For more details about what is included in each phase, please refer to Figure 2.

- The impact of 1,5 liter filtered Fontinet water on the category fossil depletion is significantly related to mine operations for the hard coal related to the production of the **activated carbon** for the filter (78%). This is again a worst case representation as most activated carbon consists of a mix of different carbons, such as coal, charcoal and carbonized coconut shells. The composition of this mix is proprietary.
- The filter housing (17%) contributes fairly to this category by the use of ABS (made out of compounds of oil and gas)
- 1,5 liter tap water production and supply (3%): the minor impact on fossil depletion is linked to the use of concrete necessary for the production and supply of tap water, and to the electricity use during the process.
- Distribution and transport to consumer (<2,5%), negligible influence.
- End-of-life (<0,5%), negligible influence.

3. PET bottled water: environmental profile

Table 2 and figure 10 show the environmental profile of the life cycle of 1,5 liter PET bottled natural sourced water in absolute figures. It shows the environmental impact per life cycle phase, per impact category. For each impact category, the impact is defined at 100%, so the relative impact of each life cycle phase is represented.

For those phases that result in an environmental credit (due to avoided material production in case of recycling or avoided energy production in case of incineration with energy recovery), this credit is presented as a negative impact in proportion to the total environmental impact.

The environmental profile is calculated in ReCiPe midpoints.

Impact category	Unit	Total	Filled PET bottle (1,5l)	Distribution	Transport retail to consumer	End-of-life
Climate change	kg CO	0,507993	0,190783	0,142942	0,173989	0,000279
Ozone depletion	m^3	2,90E-08	8,36E-09	9,91E-09	1,25E-08	-1,81E-09
Terrestrial acidification	kg oil eq	1,83E-03	9,66E-04	6,75E-04	4,50E-04	-2,57E-04
Freshwater eutrophication	kg Fe eq	9,79E-05	7,03E-05	1,12E-05	2,96E-05	-1,31E-05
Marine eutrophication	kBq U235 eq	1,05E-04	4,20E-05	3,90E-05	1,77E-05	6,47E-06
Human toxicity	kg 1,4-DB eq	0,038298	0,019784	0,005127	0,017704	-0,004318
Photochemical oxidant formation	m^{2}a	2,1E-03	6,81E-04	1,10E-03	5,08E-04	-1,85E-04
Particulate matter formation	kg NMVOC	8,00E-04	3,62E-04	3,18E-04	2,09E-04	-8,86E-05
Terrestrial ecotoxicity	kg SO	4,39E-05	1,51E-05	1,19E-05	2,07E-05	-3,73E-06
Freshwater ecotoxicity	m^{2}a	3,52E-04	4,51E-05	2,69E-05	2,22E-04	5,80E-05
Marine ecotoxicity	kg 1,4-DB eq	7,21E-04	2,68E-04	1,79E-04	3,39E-04	-6,54E-05
Ionising radiation	kg PM10 eq	0,060310	0,042017	0,010938	0,013008	-0,005653
Agricultural land occupation	m^2	0,061010	0,060000	0,002257	0,002704	-0,003951
Urban land occupation	kg 1,4-DB eq	0,015249	0,002780	0,008495	0,004485	-0,000510
Natural land transformation	kg P eq	1,06E-04	3,08E-05	3,90E-05	4,49E-05	-9,05E-06
Water depletion	kg N eq	0,733463	0,536286	0,108125	0,189916	-0,100865
Metal depletion	kg 1,4-DB eq	0,038371	0,016170	0,007393	0,019774	-0,004966
Fossil depletion	kg CFC-11 eq	0,146586	0,080206	0,049514	0,055131	-0,038265

Table 2: Absolute figures of the environmental profile of 1,5 liter water in PET bottle, characterisation, midpoint
For more details about what is included in each phase, please refer to Figure 3.

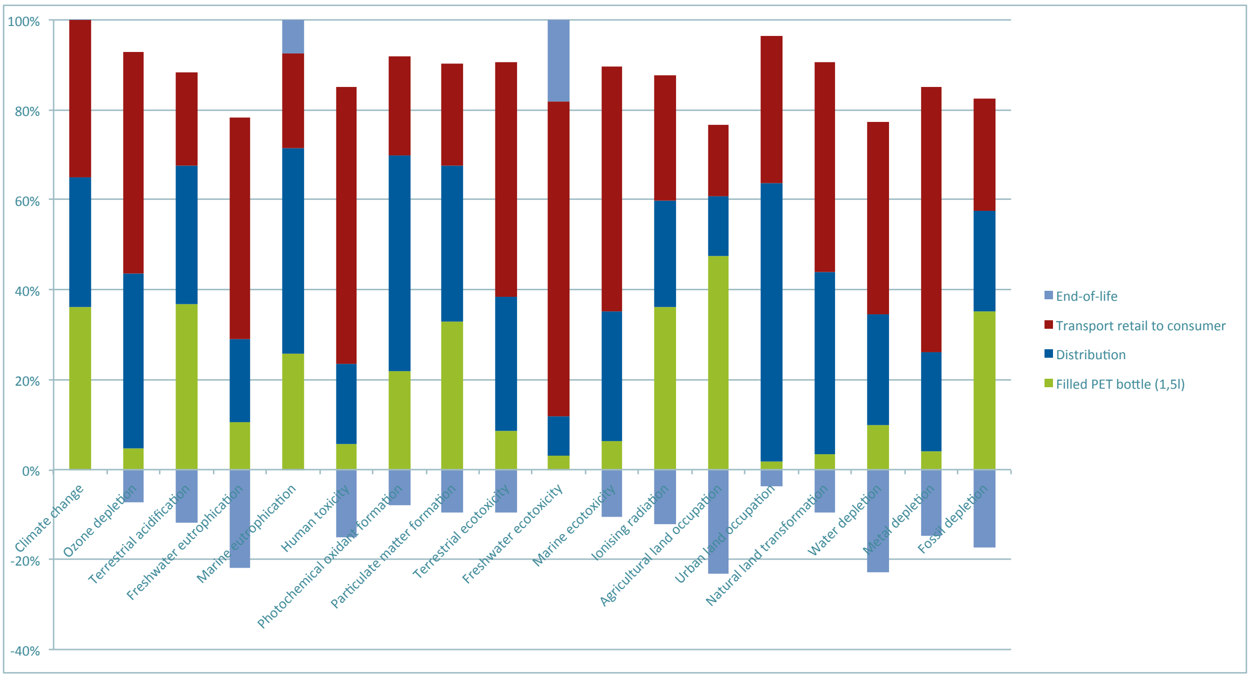

Figure 10: Environmental profile of 1,5 liter water in PET bottle, characterisation, midpoint
For more details about what is included in each phase, please refer to Figure 3.

In the life cycle of the Fontinet filtered tap water, one step in the life cycle (production of the Fontined filter) was clearly the most important.
Here, in the PET bottled natural sourced water, different steps are very important in different impact categories.

Transport from retail to consumer (car) is most important in the categories: marine eutrophication, human toxicity, terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity and metal depletion.

Distribution from bottling to retail (lorry) is most important in the category urbain land occupation.

The production and filling of the **Filled PET bottle (1,5l)** is the most important in the category agricultural land occupation.

The **end-of-life** (due to avoided material production because of recycling PET) has minor to some "negative" influence in most of the impact categories, except climate change and freshwater ecotoxicity.

Normalization

Figure 11 presents the normalized environmental profile for 1,5 liter PET bottled natural sourced water. For the following environmental impact categories the contribution caused by the life cycle of 1,5 liter PET bottled natural sourced water is relevant compared to the contribution made by economic activity in Europe:
- Natural land transformation;
- Freshwater eutrophication;
- Fossil depletion.

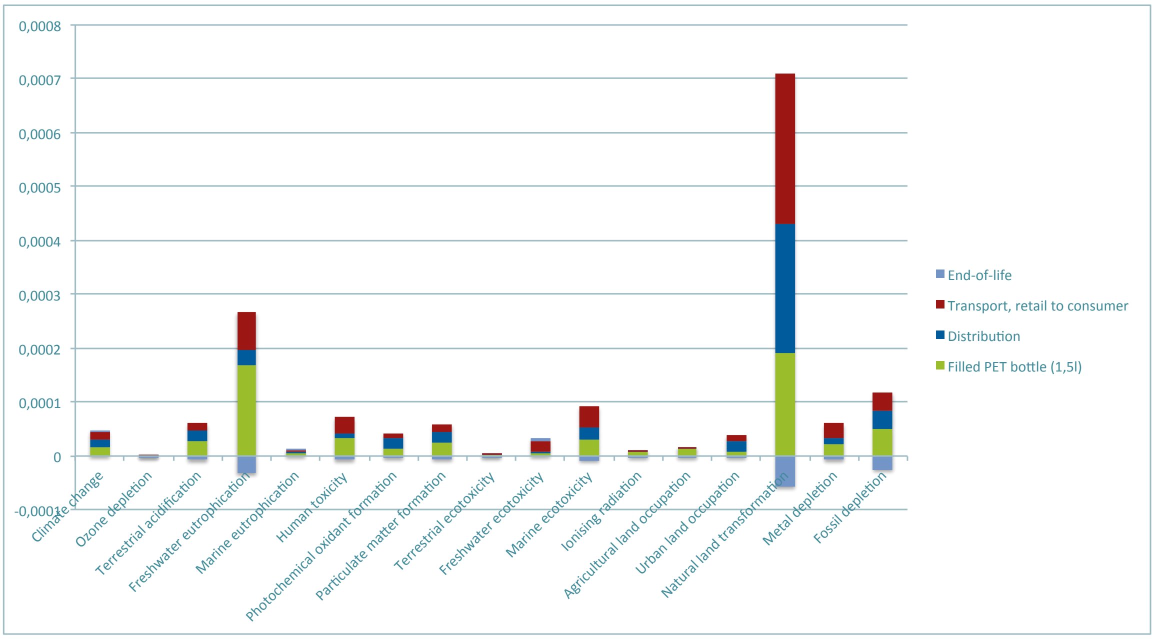

Figure 11: Normalized environmental profile of 1,5 liter filtered PET bottled natural sourced water, midpoint
For more details about what is included in each phase, please refer to Figure 3.

These 3, most important environmental impact categories are discussed below separately:

Natural land transformation

Figure 12 shows the relative importance of the different phases of the life cycle of 1,5l PET bottled natural sourced water within the impact category natural land transformation.

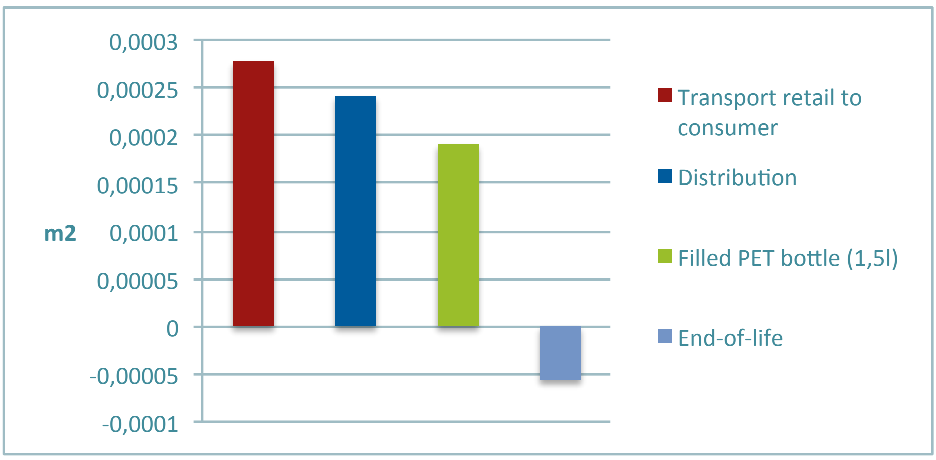

Figure 12: Environmental profile of 1,5 liter water in PET bottle ,impact category "natural land transformation'
For more details about what is included in each phase, please refer to Figure 3.

- In the category natural land transformation, following phases are very important:
  - the **transport from retail to consumer by car** (42%): it is caused by the production (on- and offshore wells) of petrol and diesel for the passenger car.
  - **distribution of the bottles to retail** (37%): caused by the production of diesel (on- and offshore wells) for the lorry used for distribution.
  - the **Filled PET bottle 1,5l** (29%): the impact on natural land transformation is related to the energy production process (on- and offshore wells) required for the production of PET.
- End-of-life (-12%): the fairly important negative impact on natural land transformation is due to avoided virgin material production as a result of recycling PET.

Fossil depletion

Figure 13 shows the relative importance of the different phases of the life cycle of 1,5l PET bottled natural sourced water within the impact category fossil depletion.

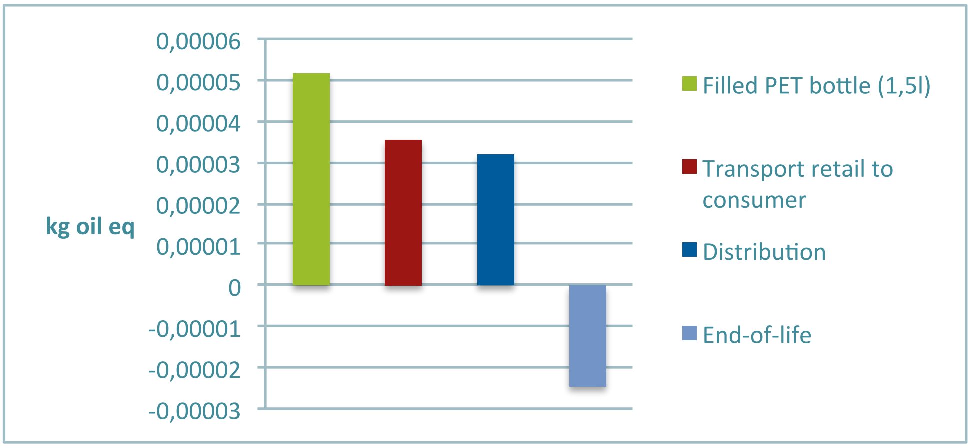

Figure 13: Environmental profile of 1,5 liter water in PET bottle, impact category 'fossil depletion'
For more details about what is included in each phase, please refer to Figure 3.

In the category **fossil depletion**, the most important impact (55%) is caused by raw materials for the **PET bottle** (xylene, ethylene).
- The **transport from retail to consumer** (car) contributes relevant with 38%: it is the depletion of fossil fuels (petrol and diesel) for driving the passenger car.
- **Distribution from bottling to retail** (34%): caused by the depletion of fossil fuels (diesel) for driving the lorry.
- **End-of-life** (-26%): the very important negative impact on fossil depletion is due to avoided virgin material production as a result of recycling PET.

Freshwater eutrophication

Figure 14 shows the relative importance of the different phases of the life cycle of 1,5l PET bottled natural sourced water within the impact category freshwater eutrophication.

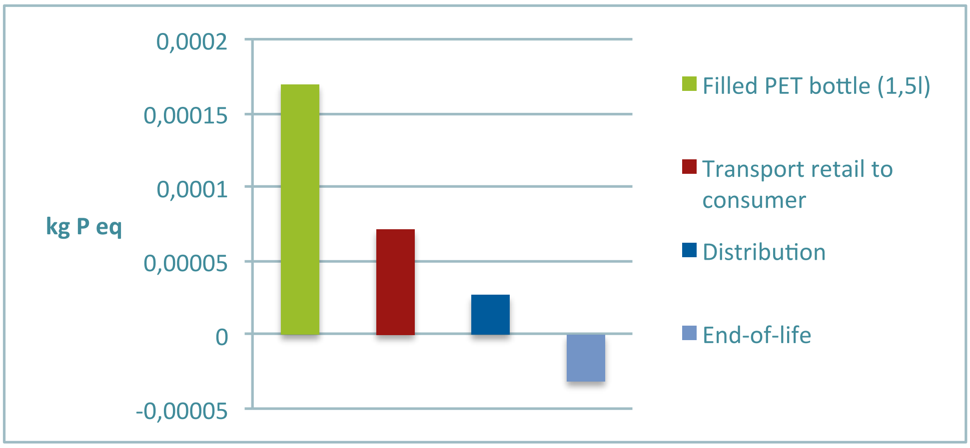

Figure 14: Environmental profile of 1,5 liter filtered Fontinet water, impact category 'freshwater eutrophication'
For more details about what is included in each phase, please refer to Figure 3.

- In the category freshwater eutrophication, the **PET bottle** is the most important with 72% of the total impact, caused by the mining activities for the production of **raw materials and electricity** for the production of PET.
- The **transport from retail to consumer** has a very important contribution of 30% to this impact category: it is caused by the mining operations to produce the raw materials (hard coal, copper, steel) for various parts of the passenger car (glider, engine).
- Distribution (11%), fairly important: the impact is caused by the mining operations to produce the raw materials (hard coal, copper, steel) for various parts of the lorry.
- End-of-life: -13%, fairly important: the negative impact on fossil depletion is due to avoided virgin material production as a result of recycling PET.

4. Comparing both types

a. <u>Methodology</u>

The environmental profiles in the previous chapters were defined in impact categories at a midpoint level ('problem oriented approach'). The uncertainty of the results at this point is relatively low. The drawback of this solution is that it leads to many different impact categories which makes the drawing of conclusions with the obtained results complex.

The damage oriented approach results in only three impact categories, which makes the interpretation of the results easier. In the comparison of both product life cycles, this approach was chosen.
At the endpoint level, most of these midpoint impact categories are multiplied by damage factors and aggregated into three endpoint categories: human health, ecosystems and resource surplus costs.

The three endpoint categories are normalized, weighted, and aggregated into a single score.[6]

Midpoint impact category	Unit	Endpoint categories	Single score
Natural land transformation	species.yr	Ecosystems	Single score
Urban land occupation	species.yr		
Agricultural land occupation	species.yr		
Marine ecotoxicity	species.yr		
Freshwater ecotoxicity	species.yr		
Terrestrial ecotoxicity	species.yr		
Freshwater eutrophication	species.yr		
Terrestrial acidification	species.yr		
Climate change Ecosystems	species.yr		
Ionising radiation	DALY	Human health	
Particulate matter formation	DALY		
Photochemical oxidant formation	DALY		
Human toxicity	DALY		
Ozone depletion	DALY		
Climate change Human Health	DALY		
Fossil depletion	$	Resources surplus cost	
Metal depletion	$		

- DALY: disabled, years of life lost
- Species.yr: damage to ecosystem (effect on species diversity).
- $: damage to resource availability (surplus energy for extraction).

[6] Handbook on Life Cycle Assessment - Operational Guide to the ISO Standards - Jeroen B. Guinée (Ed.) 2002

b. Environmental profiles compared

On figure 15, the life cycle with the highest impact is set at 100%, and the other life cycle is visualized relative to this. The midpoint characterisation factors are multiplied by damage factors, to obtain the endpoint characterisation values. In all impact categories, the impact of the Fontinet filter is significantly smaller (<10%).

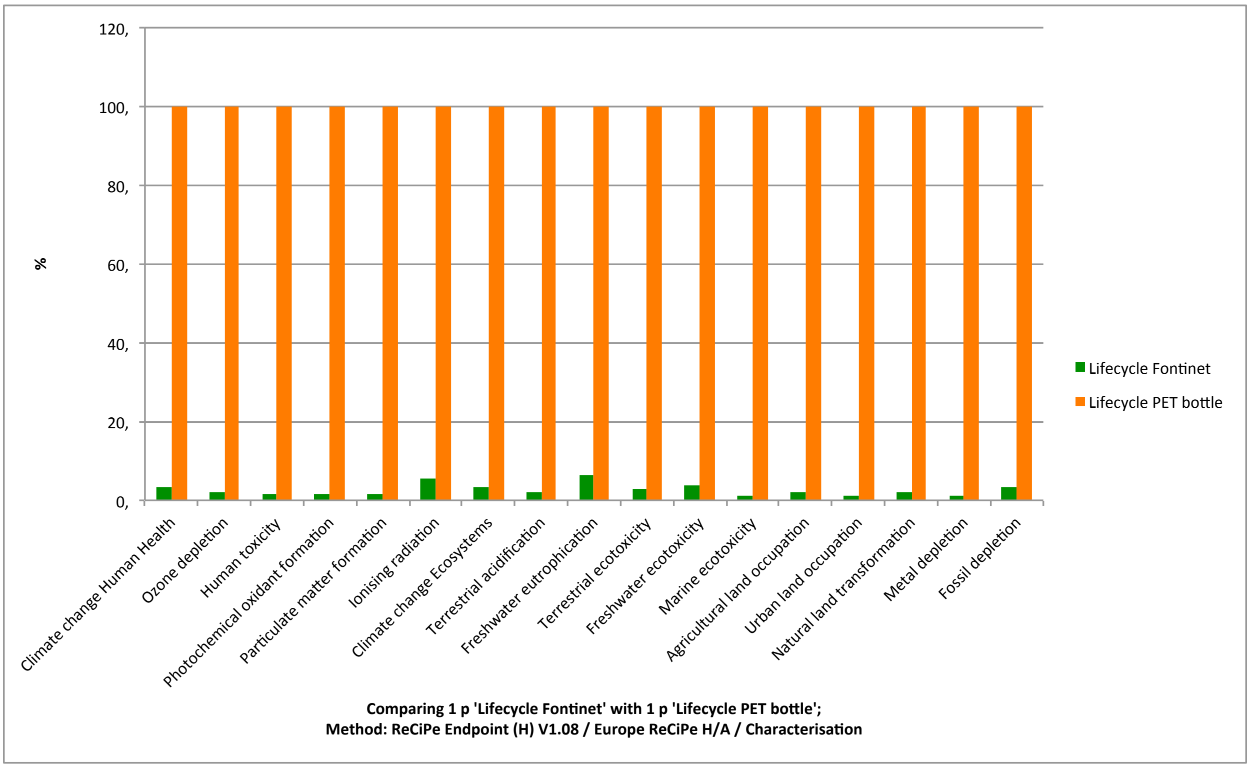

Figure 15: Comparison both life cycles per impact category, characterisation, end point

In table 4 below, some relevant absolute emissions per product life cycle are displayed.

Impact category	Unit	Fontinet 1,5l	PET 1,5l
Climate change ('carbon footprint')	kg CO	0,016	0,508
Freshwater eutrophication	kg P eq	0,00001	0,0001
Natural land transformation	m^2	0,000002	0,0001
Fossil depletion	kg oil eq	0,005	0,147

Table 4: Comparison both life cycles emissions per impact category,

Figure 16 represents the environmental profile of both life cycles, in the three endpoint categories. It is quite clear that the life cycle of 1,5l filtered Fontinet water has a significantly lower impact than the life cycle of 1,5l natural sourced water in a PET bottle.

Both life cycles have the most impact in the resources category, followed by impact on human health and damage to ecosystems.

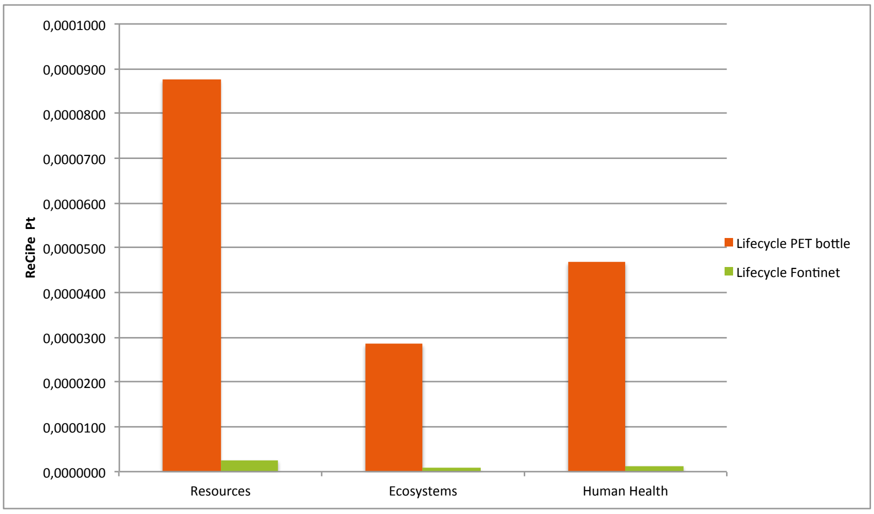

Figure 16: Comparison normalized environmental profile both life cycles, end point

These three endpoint categories are converted into a single score. This gives the following picture:

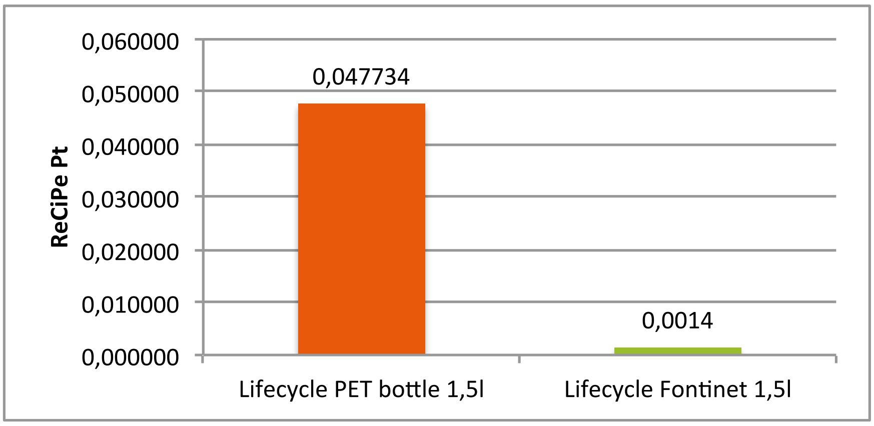

Figure 17: Comparison normalized environmental profile both life cycles, single score

The overall environmental impact of the life cycle of 1,5 liter Fontinet is 97% lower than the overall environmental impact of the life cycle of 1,5 liter natural sourced water in a PET bottle.

c. <u>Comparison per life cycle phase</u>

		Production					
Fontinet 1,5l	Total	1,5 liter tap water	Fontinet filter	Filter housing	Distribution	Transport to consumer	End-of-life
Pt.		0,000049	0,00077	0,00021			
	0,0014	0,00103			0,000035	0,000005	0,000331
% of total impact		3,5%	55,0%	14,8%			
		73,3%			2,5%	0,3%	23,6%
PET 1,5l	Total	Filled PET bottle (1,5l)			Distribution	Transport retail to consumer	End-of-life
Pt.	**0,0477**	0,022			0,014	0,016	-0,005
% of total impact		46,1%			30,1%	34,4%	-10,5%
Fontinet versus PET	Total	1,5 liter drinking water			Distribution	Transport retail to consumer	End-of-life
Difference	**-97,0%**	-95,5%			-99,8%	-100,0%	

Table 5: Comparison per life cycle phase (ReCiPe Endpoint (H) V1.08 / Europe ReCiPe H/A)
For more details about what is included in each phase, please refer to Figures 2 and 3.

Since both product life cycles are very different, it is not evident to make a comparison between similar life cycle phases. In table 5 though, different phases were grouped in order to assess the differences.

- ***Fontinet filtered tap water***

In general, the **production** of the Fontinet filter and the the Filter housing have together the most important impact in the total life cycle (69,8%).
The **end-of-life phase** of filtered Fontinet tap water contributes fairly to the total impact of the life cycle (23,6%).
The production of tap water has some influence (3,5%).
Distribution and transport to the end user are almost negligible (2,8%).

- ***PET bottled natural sourced water***

Whereas the production phase is clearly the most important in the Fontinet filtered tap water life cycle, this is more nuanced in the PET bottle natural sourced water life cycle. After subtracting the benefit from avoiding virgin material in the production phase due to the intensive PET recycling, this life cycle ends up with three almost equally (very) important phases: **production, distribution and transport**, respectively 35,5%, 30,1% and 34,4%.

The most important differences **between the two life cycles** per phase are described in the paragraphs below.

- ***The production, packaging and supply of 1,5 liter water:***

It is clear that the impact of the <u>Fontinet filter and the filter housing</u> to filter 1,5 liter tap water is significantly lower than the impact of a PET bottle. The environmental impact of a filter can be allocated to 500 liter filtered drinking water per year and the filter housing has a life span of 10 years.

Compared with the <u>PET bottle</u>, the full impact is allocated to only 1,5 liter drinking water.

- ***The distribution to a warehouse or retail:***

For Fontinet filtered water, tap water is distributed through the infrastructure of the tap water supply system. The filter is transported from the factory in Lommel to a central warehouse. The full impact of this filter distribution is allocated to 500 liter drinking water.

The PET bottle, including the water, has to be distributed with a lorry from the bottling facility to a supermarket. And again, the full impact of the distribution is allocated to 1,5 liter natural sourced water.

- ***The transport to the consumer:***

For Fontinet filtered water, tap water is distributed through the infrastructure of the tap water supply system. The filter will be delivered by a post delivery system to the end consumer. The impact of the transport to the end user of the filter can be allocated to 500 liter drinking water.

The PET bottle has to be purchased in a supermarket by each end user individually, which we assumed is done by car. And again, the full impact of the distribution is allocated to 1,5 liter natural sourced water.

- ***The end-of-life phase:***

The end-of-life phase of filtered Fontinet tap water has a fairly important contribution to the total impact of the life cycle (23,6%). There is no specific recycling for any of the materials (only those in the standard BE waste scenario, smaller fractions of cardboard or plastics).

Compared with the end-of-life of the 1,5 liter natural sourced water in a PET bottle, one can observe an negative environmental impact (-10,5%), thanks to the high recycling rate of PET (71%)[7].

d. Top five process contribution for the Fontinet life cycle

The top five of the most important process contributions is displayed in table 6 for the Fontinet filtered tap water. This top 5 gives some useful insights in how the life cycle of the Fontinet filter can be made even more beneficial in the future.

Fontinet	Pt.	% of total impact	Life cycle phase
1. Municipal solid waste (waste treatment) {BE}, incineration	0,000318	22,8%	End-of-life
2. Hard coal	0,000295	21,1%	Raw materials filter
3. Acrylonitrile-butadiene-styrene copolymer	0,000139	10,0%	Raw materials filter housing and filter
4. N-methyl-2-pyrrolidone	0,000098	7,0%	Raw material filter
5. Electricity, low voltage, at grid/BE S	0,000098	7,0%	Energy required in production process
Total impact		**0,0014**	

Table 6: Top five process contribution Fontinet filtered water

The conclusion we can draw from this table is that to make the Fontinet an even more sustainable choice, following recommendations can be made:

- install a recycling program for the Fontinet cartridges in order to augment the recycling rate of the embedded materials.
- make an informed choice of supplier for the activated carbon (and other components of the filter);
- reduce the weight of the filter housing (1 kg ABS);
- purchase of green electricity at Primewater.

[7] Fostplus 2012

Uncertainty & Sensitivity analysis

In order to use the results from this study for public communication or decision-making, information is needed on the robustness of the results. This element of the interpretation phase assesses the influences on the results of variations in process data, model choices and other variables.

The **uncertainty analysis** uses empirical data on the uncertainty ranges of specific data to calculate the total error range of the results.

In the **sensitivity analysis**, these changes are deliberately introduced in order to determine the robustness of the results with regard to these variations.

1. Uncertainty analysis

The Ecoinvent data can be changed to the unit processes database instead of system processes database. This allows a Monte Carlo analyse to use the specified uncertainties for all LCI parameters available from Ecoinvent data.

a. <u>Results</u>

Figure 18 displays the results of the uncertainty analysis. Calculations are run with random variations in the different uncertainties on the parameters used from the databases (Ecoinvent). The aim is to test if the conclusions from previous chapter still stand when known uncertainties are taken into account.

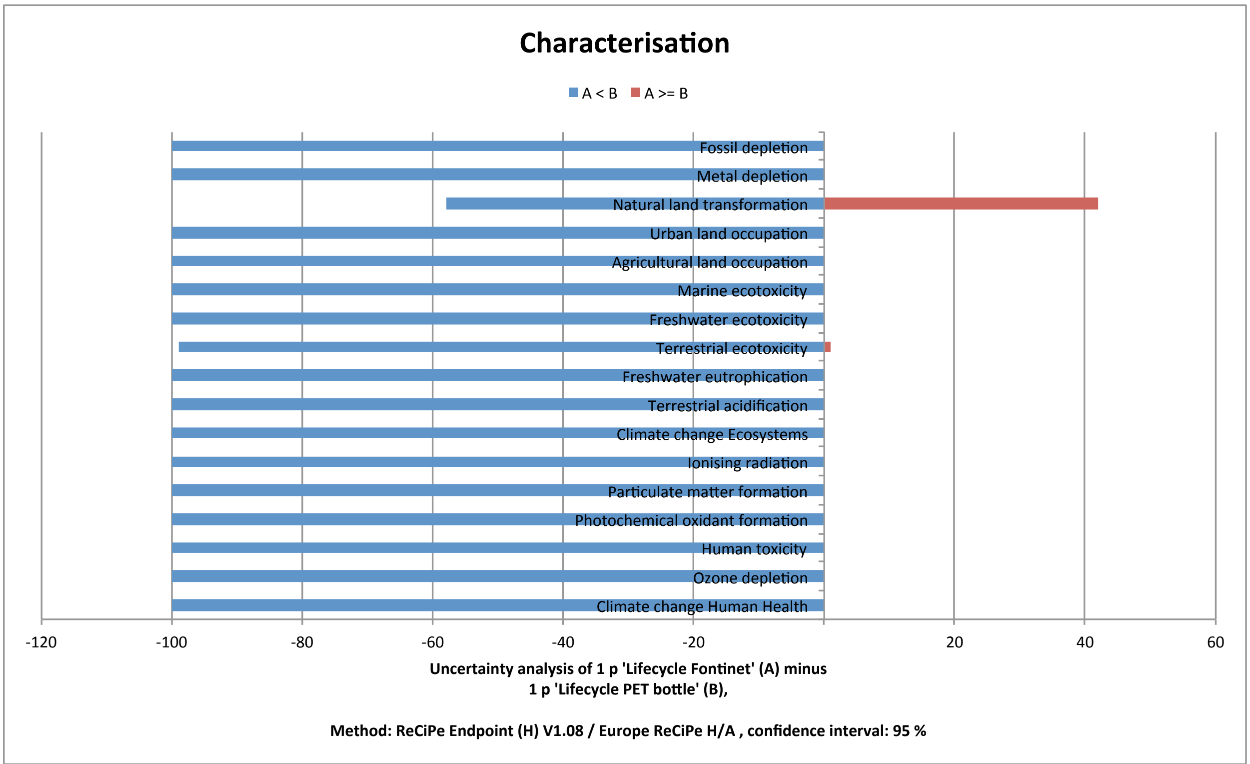

Figure 18: Uncertainty analysis, characterisation

For all characterisations, except one, the uncertainty analysis confirms the environmental benefit of the Fontinet filtered tap water over the PET bottled natural sourced water.
The uncertainty in the characterisation "Natural land transformation" is the highest with 42% of the results in favor of the PET bottle scenario. These specific cases combine a higher impact caused by the activated carbon in the Fontinet filter with a lower impact on transport, distribution and/or production of the PET bottle.

Figure 19 shows the results of the uncertainty analysis as the difference between the Single End scoring between the Fontinet filtered tap water and the PET bottled natural sourced water. The results are displayed in difference in ReCiPe Points in the X-axis and the probability of which a result occurs in the Y-axis.

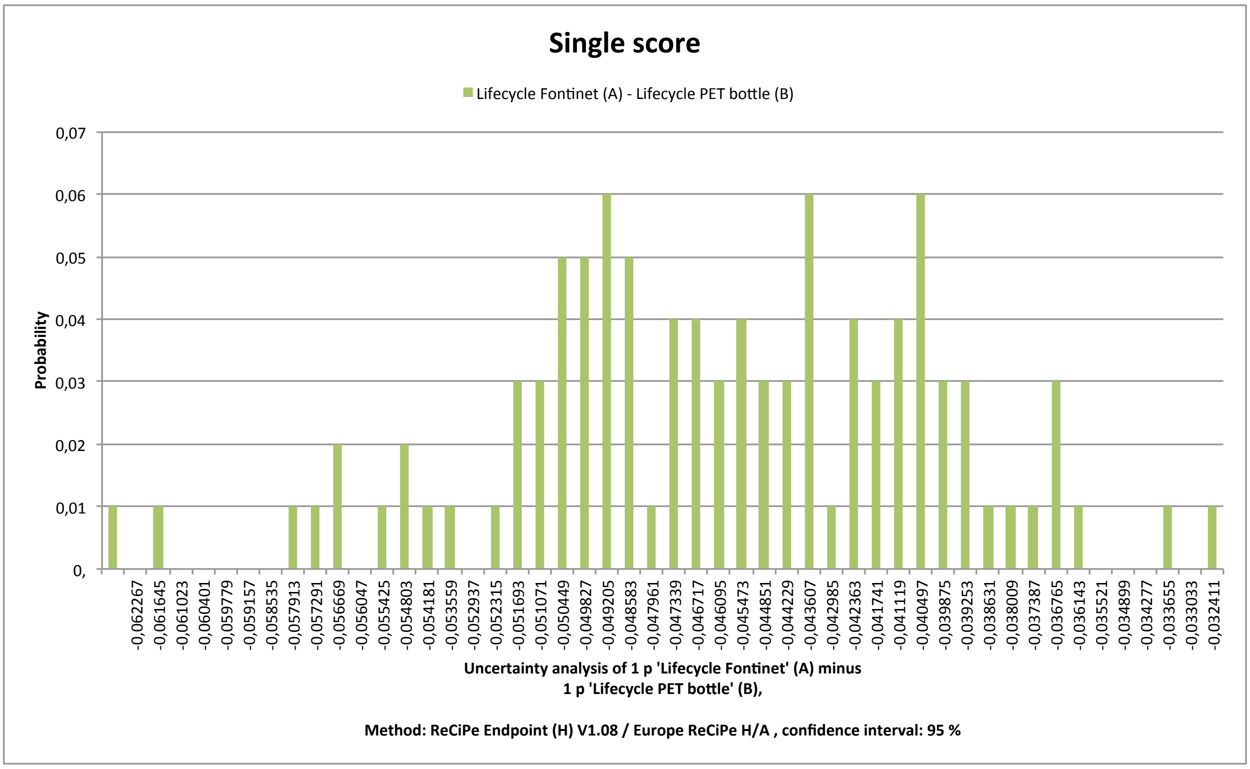

Figure 19: Uncertainty analysis, single score

This difference is always negative, meaning an overall beneficial result in favor of the Fontinet filtered water scenario.

2. Sensitivity analysis

The use of parameters in SimaPro makes it possible to test the influence of certain assumptions that were made to model the Fontinet filtered tap water and the PET bottle water, using parameter sets in the calculation setup.

a. 1,5l Fontinet filtered water

Table 7 gives an overview of the different parameters and the different parameter sets used.

- Set Ref: in this set the two parameters are identical to the values in the LCI tables used earlier and discussed in the life cycle impact assessment.
- Set 1: the situation where less filtered water would be used for drinking in combination with a location close to the Primewater production plant.
- Set 2: the situation where less filtered water would be used for drinking in combination with a location further away from the Primewater production plant.
- Set 3: the situation where more filtered water would be used for drinking in combination with a location close to the Primewater production plant.
- Set 4: the situation where more filtered water would be used for drinking in combination with a location further away from the Primewater production plant.

Parameter name	Unit	Set 1	Set 2	Set Ref	Set 3	Set 4	Comment
Drinkrate	l/filter	250	250	500	750	750	Fontinet: amount of liters used for drinking/filter
Distancefontinetwarehouse	km	100	1000	500	100	1000	Fontinet: Km from Primewater to warehouse

Table 7: Parameter sets 1,5l Fontinet filtered tap water

b.<u>Results</u>

Figure 20 displays the results of running the life cycle analysis with the different parameter sets explained in Table 7. Set Ref (green) is the same as discussed before in the Chapter Life Cycle Impact Assessment. The normalized environmental profile is shown at midpoint environmental impact categories for this reference set, as well as the 4 other data sets.

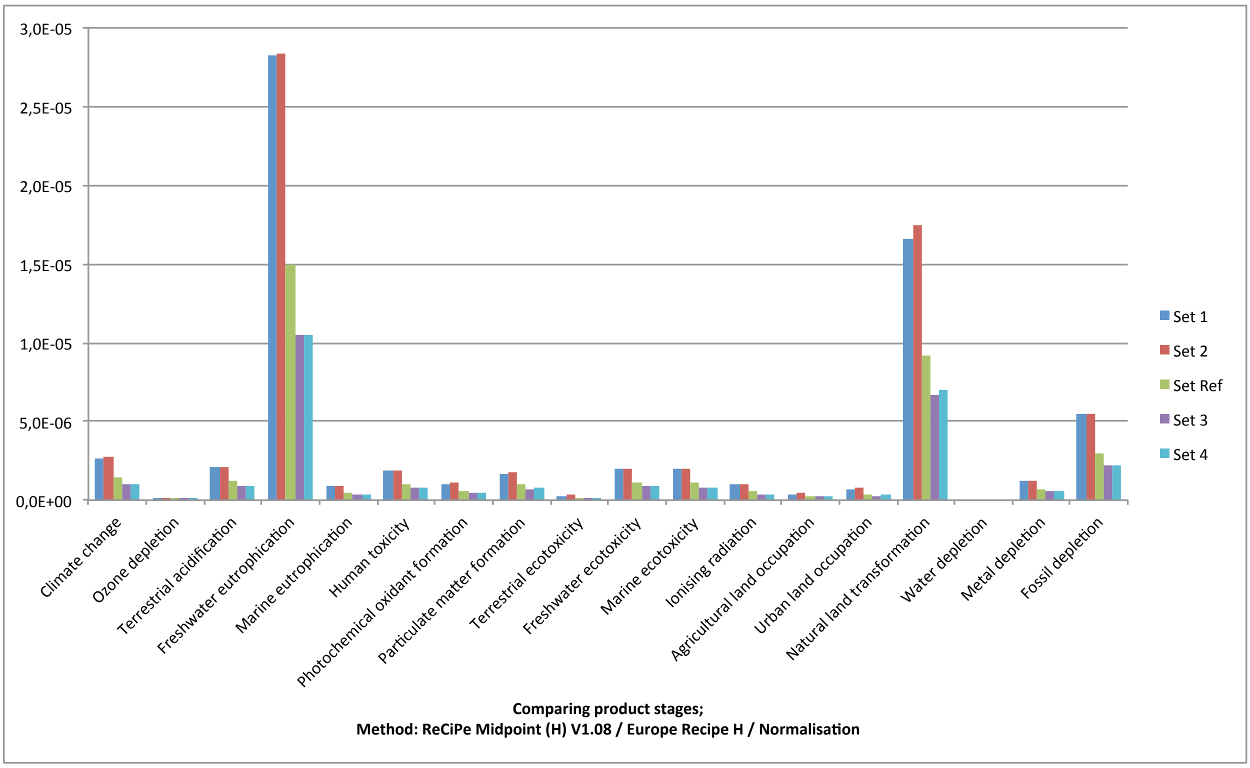

Figure 20: Fontinet filtered water, sensitivity analysis, normalization

Main conclusions:

- The **most important impact categories remain unchanged**: freshwater eutrophication, natural land transformation and fossil depletion.
- The parameter that sets the **amount of liters used for drinking is far more sensitive** for the overall result than the parameter that sets the distance from Primewater to the warehouse nearby the end consumer.

c.1,5l PET bottle water

Table 9 gives an overview of the different parameters and the different parameter sets used.

- Set Ref: in this set the two parameters are identical to the values in the LCI tables used earlier and discussed in the life cycle impact assessment.
- Set 1: the situation with natural sourced water from a local supplier.
- Set 2: the situation with natural sourced water from a distant supplier.
- Set 3: the situation were the recycling rate for PET is only 30%.
- Set 4: the situation were the distance travelled by car to the supermarket/store is reduced and the items purchased per visit raised.

Parameter name	Unit	Set 1	Set 2	Set Ref	Set 3	Set 4	Comment
Distancenatural sourcedretail	km	100	2000	500	500	500	PET bottle: Km from filling to retail
Cartoretail	km	16	16	16	16	5	PET bottle: Km from end consumer to supermarket/store/...
Itemspurchased	pcs	30	30	30	30	40	PET bottle: Items purchased during 1 supermarket visit
RecyclingPET	%	71	71	71	30	71	PET bottle: Spread of different recycling rates for PET throughout European countries

Table 8: Parameters and parameter sets 1,5l PET bottled water

d.Results

Figure 21 displays the results of running the life cycle analysis with the different parameter sets explained in Table 8. Set Ref (green) is the same as discussed before in the Chapter Life Cycle Impact Assessment. The normalized environmental profile is shown at midpoint environmental impact categories for this reference set, as well as the 4 other data sets.

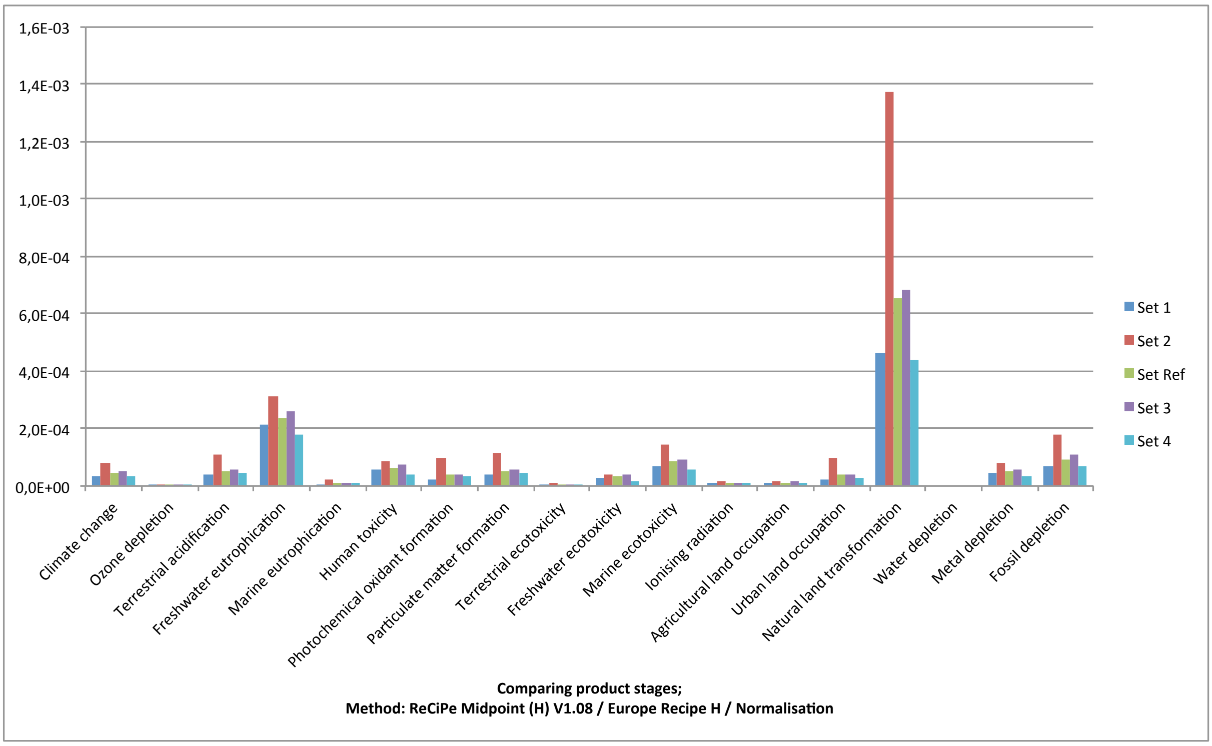

Figure 21: PET bottle water, sensitivity analysis, normalization

Main conclusions:

- **Natural land transformation, fossil depletion and freshwater eutrophication** remain in the different parameter sets the most contributing impact categories.
- Set 1: using water from a local natural sourced water source (100 km) reduces the result in all impact categories versus Set Ref, but not dramatically.
- Set 2: the impact on natural land transformation almost doubles due to the strong raise of Ton.km travelled by the water bottle between filling plant and the retail (2000 km).
- Set 3: the reduced recycling rate has a limited impact.
- Set 4: the reduced effect from passenger car traveling is noticeable in most of the impact categories.

Considering the PET bottled natural sourced water, **the distance the filled bottle travels by lorry** becomes the most important parameter and contributing phase in the life cycle when this distance increases.

3. Comparing Endpoint Single scoring

At the end of the chapter Life Cycle Impact Assessment the single end scorings of the two life cycles where compared with each other and a reduction of 97% was concluded, when moving from consuming 1,5l PET bottled natural sourced water to 1,5l Fontinet filtered tap water.

This means that for the same ecological impact of one 1,5l PET bottled natural sourced water 50l Fontinet filtered tap water can be consumed. Which is a beneficial factor of 33.

Running the life cycle sensitivity analysis with the ReCiPe Endpoint method, with the different parameter sets as described in tables 7 & 8, makes it possibles to nuance this factor 33 for the different user profiles.

a. 1,5l Fontinet filtered water

Figure 22 displays the ReCiPe Endpoint results for the different parameter sets from table 7.

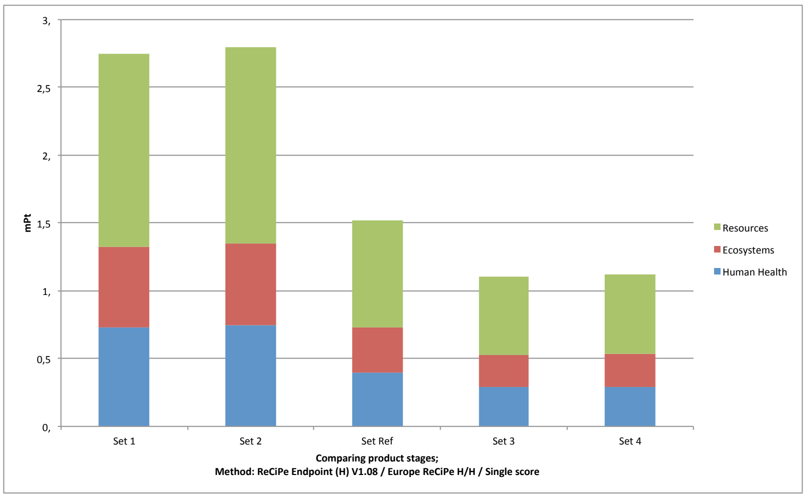

Figure 22: Fontinet filtered water, sensitivity analysis, single score

b. 1,5 l Pet bottle water

Figure 23 displays the ReCiPe Endpoint results for the different parameter sets from table 8.

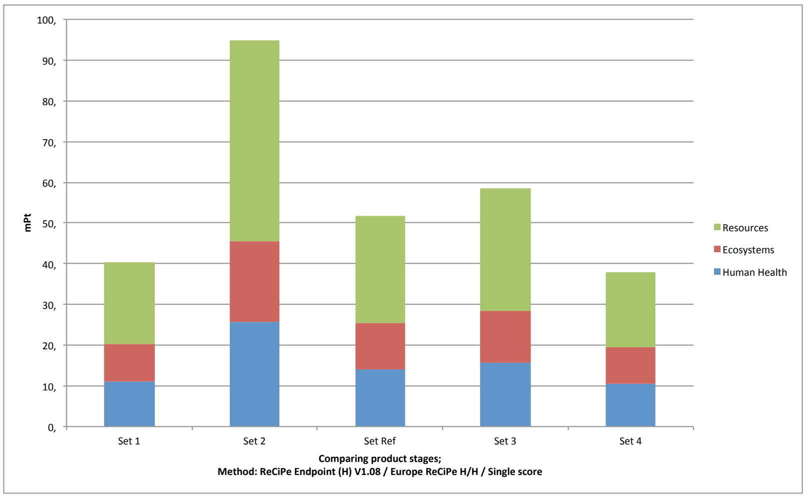

Figure 23: PET bottle water, sensitivity analysis, single score

Comparing the results from figures 22 and 23, following differentiating remarks can be made:

- The **maximum beneficial factor = 80** is achieved when comparing the parameter set with the highest scoring for a PET bottled natural sourced water with the parameter set with lowest scoring for a Fontinet filtered tap water scenario.
  This could be the situation where:
  - a family that used to drink more than an average amount of natural sourced water (750 l/y);
  - and the natural sourced water came from a very distant source (2000 km);
  - and is living nearby the Primewater production plant (100 km).

  For instance: a family, living in the province of Antwerp, drinking lots of Italian natural sourced water.

- The **minimum beneficial factor = 13** is achieved when comparing the parameter set with the lowest scoring for a PET bottled natural sourced water with the parameter set with highest scoring for a Fontinet filtered tap water scenario.
  This is a situation with:
  - a family that used to drink less than an average amount of natural sourced water (250 l/y);
  - and the natural sourced water came from a local source (100 km);
  - living nearby the supermarket where they bought the water (5 km);
  - but far away from the Primewater production plant (2000 km).

  For instance: a family, living in an Italian city, drinking modestly, local Italian natural sourced water.

The same three midpoint impact categories are dominant in both product life cycles: natural land transformation, freshwater eutrophication and fossil depletion.

In the Fontinet filter life cycle, the activated carbon is the most contributing component. This is a worst case representation as most activated carbon consists of a mix of different carbons, such as coal, charcoal and carbonized coconut shells. The composition of this mix is proprietary.

In the PET bottle life cycle the very important contributors are the transport and distribution of the filled bottle and the production of PET.

4. Recommendations

The Fontinet filter should not be installed systematically when it is uncertain that the Fontinet filter will be used for drinking purposes. It is clear that the environmental burden allocated to 1,5l of drinking water increases rapidly with a diminishing yearly amount of Fontinet filtered water used for drinking purposes.

In order to make the Fontinet an even more sustainable choice, following recommendations can be made:

4. stimulate the full use of the 1 year filtering capacity (4000 liter) of the Fontinet filter for drinking purposes substituting PET bottled natural sourced water.
5. install a **recycling program** for the Fontinet cartridges in order to augment the recycling rate of the embedded materials. For distant use of the product (distance from Primewater production), a comparison should be made first between such a recycling program and standard waste scenario.
6. make an informed choice of **supplier for the activated carbon** (and other filter components);
7. reduce the weight of the **filter housing** (1 kg ABS);
8. purchase of **green electricity** at Primewater.

Conclusion

Overall, the environmental benefit of drinking 1,5l Fontinet filtered instead of 1,5l PET bottle natural sourced water is absolutely clear. An uncertainty analysis does not change this outcome.

Comparing the endpoint single scorings, one can state that one 1,5l PET bottle natural sourced water has a similar environmental burden as 50l Fontinet filtered water, which is a **beneficial factor of 33**.

Annex: Review statement final report LCA Fontinet (VITO)

Distribution: Restricted

Final report

Final review statement on report “Comparative LCA assessment of Fontinet filtered tap water vs. Natural sourced water in a PET bottle”

Evelien Dils

March 2014

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CHAPTER 1 INTRODUCTION

In this document the draft final report of the study "Comparative LCA assessment of Fontinet filtered tap water vs. Natural sourced water in a PET bottle" is reviewed against the ISO 14040 and 14044 standards. This study compares the environmental impacts of water used by households for drinking purposes delivered by municipal tap water filtered by a Fontinet system versus natural sourced water from single use disposable PET bottles. The external expert review is done considering the comparative character of the LCA study and the aim to use the results for communication purposes. Based on the responses of Futureproofed on all review statement reports, a final review report will be made by VITO.

According to the ISO 14040 and 14044 standards, the critical review process shall ensure that:

- the methods used to carry out the LCA are consistent with the ISO standard;
- the methods used to carry out the LCA are scientifically and technically valid;
- the data used are appropriate and reasonable in relation to the goal of the study;
- the interpretations reflect the limitations identified and the goal of the study;
- the study report is transparent and consistent.

CHAPTER 2 REVIEW STATEMENT ON THE DRAFT FINAL REPORT

2.1. DESCRIPTION OF THE REVIEW PROCEDURE FOLLOWED

Futureproofed provided the draft final report of the study, for each of the stages of the LCA study: goal & scope definition, life cycle inventory assessment, life cycle impact assessment and interpretation. VITO formulated review comments, listed actions to take and prepared additional questions where needed. The recommendations and questions of the VITO reviewer were included in three review statements, which is shown as a whole in Annex A. Futureproofed gave feedback on these review statements to VITO (shown in blue in Annex A) and made an update of the LCA study. Finally, VITO made this final review statement, based on the report on Fontinet filtered tap water received on the 27th of February 2014.

2.2. FINAL REVIEW STATEMENT

Overall, the report of the study "Comparative LCA of Fontinet filtered tap water vs. Natural sourced water in a PET bottle" complies with the ISO 14040 and 14044 standards. The methods used to carry out the LCA are scientifically and technically valid. The assumptions that were made are explained and justified and the limitations of the study are sufficiently described. The (non-confidential) data are reported in a transparent manner. Data quality and sources are in accordance with the goal and scope of the study. The interpretation of the results is consistent with the goal of the study. A number of sensitivity analyses were made to assess the robustness of the results. A rough check of the validity of the results was done, which indicates the calculations are performed in a good manner.

The authors have been very helpful to answer questions and provide data and have taken into account the main comments and recommendations of the reviewer. The main issues that were raised by the reviewer and addressed by Futureproofed are the following:

- a more elaborate description of the function of the system was given;
- a more detailed description of system boundaries completed with graphical representations of both systems was provided;
- data quality has been discussed more thoroughly;
- thorough explanation of graphs and figures in the LCIA was given;
- clear reference to information sources was added.

The reviewer found the overall quality of the methodology and execution of the study appropriate for the goal and scope of the study. The study gives an adequate overview of the environmentally relevant data for the two systems under study. The environmental impact of the water for drinking purposes in both systems is calculated and assessed in a transparent and consistent way.

When communicating the results of the study, one should bear in mind that ISO only recommends the use of results on the midpoint impact category level. Weighted results should not be used for communication purposes. Since in this study, the results are very clear no matter what impact category one wishes to focus on, there should be no problem in clearly communicating the results on that level.

References

ISO 14040, 'Environmental management – Life cycle assessment – Principles and framework', (2006).
ISO 14044, 'Environmental management – Life cycle assessment – Requirements and guidelines', (2006).