

reWINE

Reutilització d'ampolles de vidre al
sector vitivinícola del sud d'Europa

CONCLUSIONS FROM THE ENVIRONMENTAL MONITORING

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Executive Summary

Waste management is one of the biggest environmental challenges of modernity and is affecting worldwide communities. Industries and policy makers concerned about the environmental impact and consequences of domestic product packaging. This concern shows the importance of reducing packaging waste in order to avoid environmental pollution and to follow the sustainability standards of national and international legislation. Even though Spain meets the recycling rate established by Directive 94/62, the reuse of glass bottles is almost negligible, only the sector of Hotels, Restaurants and Catering (HoReCa) reuse glass bottles (non-alcoholic beverages) but in small scale projects developed by private companies. There is not information about the reuse of glass bottles in the HoReCa sector for wine bottles, and, regarding the scope of reWine project, same can be said for those wine bottles that can be found in retail (small shops or supermarkets), where the reuse is not a current practice. This report presents a summary of the environmental analysis performed during the project.

From the environmental perspective, it should be remarked that for all case studies included in the reWine pilot tests, the return system provides environmental benefits.

The environmental benefits can be higher or lower, depending on the distance between the wineries and washing facilities and the number of washings required to ensure that the bottle is ready for a new use. For instance, regarding the specific impact concerning carbon footprint (Global Warming Potential, expressed in kg of CO₂ equivalent), accumulated savings after 8 reuses (7 washings) vary from 1,91 to 3,68 kg CO₂ eq /bottle, depending on the winery, the logistics or the distance from/to the washing facilities.

Summary of the GWP savings for 8 reuses

SCENARIOS	CASE STUDIES	Min CO ₂ savings (kg CO ₂ eq/bottle)- real distance	Max CO ₂ savings (kg CO ₂ eq/bottle)- optimal distance	Average CO ₂ savings (kg CO ₂ eq/bottle)
A. HORECA	A1. MEDIUM SIZE WINERY	2,54	3,68	3,11
	A2. LARGE WINERY	2,09	3,31	2,70
B. LARGE RETAIL+ logistics	B1. MEDIUM SIZE WINERY AND RETAIL	2,02	2,37	2,20
	B2. SMALL SIZE WINERY AND RETAIL	2,20	3,50	2,85
C. Small retail + wine tasting	C1. SMALL WINERY AND TASTE	1,90	3,54	2,72
	C2. SMALL WINERY AND LOCAL STORES	1,66	3,63	2,65
D. Integrated washing	D1. SMALL WINERY AND INTEGRATED WASHING	2,32	2,32	2,32
E. Retail+ waste collection point	E1. MEDIUM SIZE WINERY+RETAIL	2,39	3,55	2,97
	E2. LARGE WINERY+RETAIL	1,91	3,19	2,55

The reduction in the distance between the winery and the washing facility provides additional benefits to the remaining environmental impact categories. For the remaining impact categories, savings are also significant. A special analysis should be done for the Abiotic Depletion Potential (elements) impact category, as this impact depends clearly on the fuel consumption in the transport. For this reason, savings on this impact category are found if distances are reduced. For this purpose, this study suggests that the creation of new washing facilities, spread along the territory and to have at least one in each Certification of Origin of wine, will enhance the obtaining of comprehensive environmental benefits.

1. Introduction

Waste management is one of the biggest environmental challenges of modernity and is affecting worldwide communities. In Spain, packaging waste represents approximately 30% of municipal solid waste by weight and from that percentage the 68% is recycled (Eurostat, 2015). In the region of Catalonia glass packaging represent 5% of municipal solid waste by weight (Agencia de Residuos de Catalunya, 2019). As a result of these statistics, industries and policy makers are concern about the environmental impact and consequences of domestic product packaging, therefore best practices related to the protection of resources and minimizing the ecological impact arising from production and consumption as well as from the disposal of products are becoming important in order to implement improvements that promote sustainability.

The 94/62/EC (European Parliament and Council Directive, 2005) directive on packaging and packaging waste puts as first priority preventing the production of packaging waste and, as additional fundamental principles, reusing packaging, recycling and other forms of recovering packaging waste before the final disposal. In Spain the glass recycling rate is 68%, which meets the target of recycling established by Directive 94/62 / EC, before December 31, 2008. The European Strategy for Plastics in a Circular Economy is a recent initiative whose proposal is to initiate work on harmonized rules to ensure that by 2030 all plastics packaging placed on the EU market can be reused or recycled in a cost-effective manner (European Commission, 2018); this new initiative will affect specially to the private sector because packaging must be reinvented and new opportunities for investment and generation of jobs will be created. Also, this strategy on plastics can also broader the use of glass packing and at the same time increase the reuse of glass packaging by making it cost-effective lying on the new frame of circular economy.

This study is focused on the reuse of glass bottles which are used to pack a variety of beverages, but our interest stands in the wine industry. Catalonia consumes 9 million bottle beverages where 6% correspond to wine bottles. The industry of wine in Spain represents the 14% of land for cultivation in a global scale and is the third country in wine production after France and Italy (International Organisation of Vine and Wine, 2017). In 2017 sales in Spain were 643,102 thousand of liters and 89,597 thousand of liters were sold in the region of Catalonia (Generalitat de Catalunya, 2017).

The main objective of this deliverable is to evaluate the feasibility of wine glass packaging reuse in the region of Catalonia considering the technical, environmental and economic perspective.

This research study is structured as follows. Section 2 mentions the material and methodology use to evaluate the environmental feasibility of reuse glass bottles in the wine sector in the region of Catalonia. Section 3 presents the information collected from the companies involved in the project showing the assumptions and calculations that had to be done to get the information organized and ready for the environmental economical assessment. This is followed by Section 4 that contains results and discussions, while Section 5 summarizes and concludes the study while also offering suggestions for future research based on the evidence presented in Section 4.

2. Methodology

2.1 Environmental feasibility assessment

The environmental feasibility study has been carried out using the Life Cycle Assessment methodology. Life Cycle Assessment (LCA) is an analysis of the environmental impact of a product, process, or activity over the course of its lifetime by identifying and quantifying the energy and materials used and wastes released to the environment. There are two standards for LCA created by the International Organisation for Standardisation (ISO): ISO 14040 (Environmental management - Life cycle assessment - Principles and framework) and ISO 14044 (Environmental management - Life cycle assessment - Requirements and guidelines). LCAs have four distinct steps, shown in Figure 1 below.

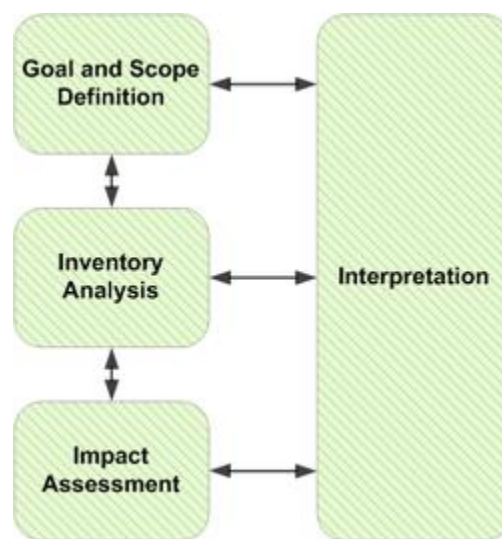


Figure 1 LCA structure defined by ISO 14040

2.2.1 Goal and Scope Definition

In the definition of the goal the intended application, purpose, and intended audience should be clearly laid out as well as if the LCA results are meant to be used for comparative reasons. The scope definition involves characterization of the system, definitions of all assumptions made, and explanation of the methodology used to set up the system. The scope is also where the functional unit is defined, the system boundaries are set, any data requirements are explained, limitations are stated, and many more definitions are laid out.

In the reWine project, the goal is to compare the environmental performance of the reuse model for wine bottles, compared to use single-use bottles.

Functional Unit

In any LCA, a functional unit is needed especially when it comes to comparison studies. The functional unit is the quantified definition of the function of the product. When comparing two systems or products their functional unit must be the same for the comparison to be valid.

For this assessment, the chosen functional unit is “500 wine bottles”. Therefore, data for the assessment and results will be given considering 500 wine bottles. In any case, results are further reported per wine bottle.

System Boundaries

The system boundaries of the LCA define which processes are included in the system, such as the production, use, and EOL processes. In this study, the “cradle to grave” option for system boundaries definition has been chosen (Figure 2 and Figure 3).

The system boundaries of the assessment in the reWine pilot tests are defined by the following figures, depending if the assessment is carried out for a single-use bottle or for the reusable bottle.

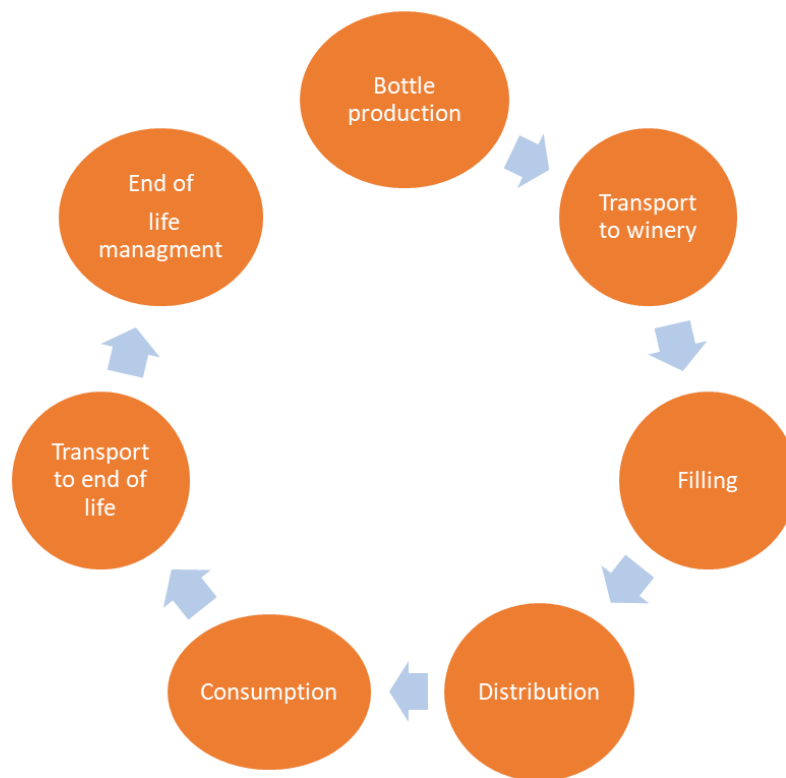


Figure 2 System boundaries for a single-use bottle

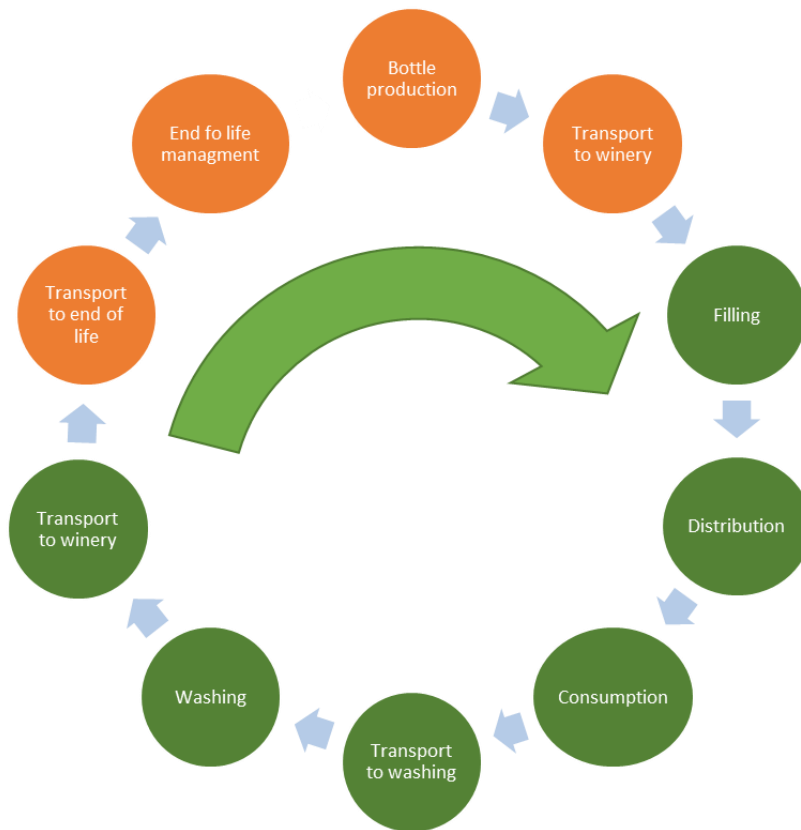


Figure 3 System boundaries for a reusable bottle

In detail the life cycle stages that have been considered are shown in Figure 4:

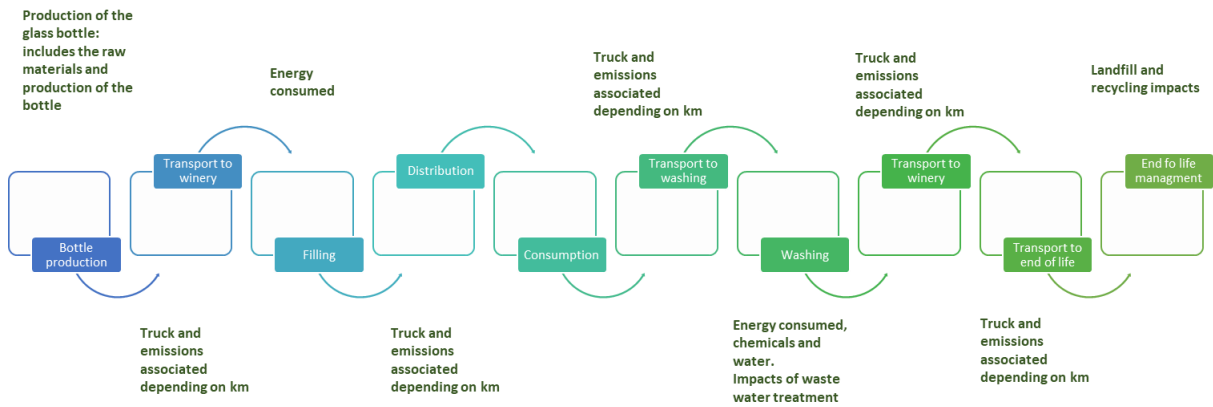


Figure 4 Life cycle stages included in a reusable wine bottle

2.2.2 Inventory Analysis

In this step of the LCA, the inputs and outputs for the system throughout its entire life cycle are compiled and quantified. It involves data collection and compiling the data in a Life Cycle Inventory (LCI) table.

The complete inventory is provided in the next sections of this document, referred to each case study and scenario.

2.2.3 Impact Assessment

The Life Cycle Impact Assessment (LCIA) identifies and evaluates the amount and significance of potential environmental impacts arising from the life cycle inventory.

For this assessment, the following impact categories have been chosen:

- Abiotic depletion, measured in kg Sb eq: contributes to the depletion of non-renewable resources
- Abiotic depletion (fossil fuels) measured in MJ: contributes to the depletion of fossil resources
- Global warming (GWP100a) measured in kg CO₂ eq: contributes to the atmospheric absorption of infrared radiation
- Ozone layer depletion (ODP) measured in kg CFC-11 eq: contributes to the depletion of stratospheric ozone
- Human toxicity measured in kg 1,4-DB eq: contributes to conditions toxic to humans
- Fresh water aquatic ecotoxicity measured in kg 1,4-DB eq: contributes to conditions toxic to fresh water
- Marine aquatic ecotoxicity measured in kg 1,4-DB eq: contributes to conditions toxic to oceans
- Terrestrial ecotoxicity measured in kg 1,4-DB eq: contributes to conditions toxic to ground
- Photochemical oxidation measured in kg C₂H₄ eq: contributes to photochemical smog
- Acidification measured in kg SO₂ eq: contributes to acid deposition
- Eutrophication measured in kg PO₄--- eq: provision of nutrients contributing to biological oxygen demand

2.2.4 Interpretation

After the LCIA is performed, the results are evaluated to assure that they are consistent with the goal and scope definition and to ensure that the study has been completed. This interpretation phase encompasses two parts: identification of significant issues and evaluation.

In the reWine assessment, specific indicators have been further analysed, to understand the influence of the different life stages and elements to the results. Furthermore, sensitivity analysis has been performed to check the consistency of the obtained results and how they may change if the original data is varied. Specifically, results have been calculated considering more than 1 washing per cycle of reuse and varying the distance between the washing plant and the winery.

3 Inventory and calculations

In this section the four scenarios will be explained as well as the inventory and assumptions made for this study.

3.1 Scenarios

The following case studies have been analysed and grouped in 5 scenarios Table 1:

Table 1 Case studies and scenarios included in the assessment

SCENARIO	CASE STUDIES
A. HORECA	A1. MEDIUM SIZE WINERY A2. LARGE WINERY
B. Large retail+ logistics	B1. MEDIUM SIZE WINERY AND RETAIL B2. SMALL SIZE WINERY AND RETAIL
C. Small retail + wine tasting	C1. SMALL WINERY AND TASTE C2. SMALL WINERY AND LOCAL STORES
D. Integrated washing	D1. SMALL WINERY AND INTEGRATED WASHING
E. Retail+ waste collection point	E1. MEDIUM SIZE WINERY+RETAIL E2. LARGE WINERY+RETAIL

Scenario A: HORECA and local retail: large and medium size wineries

This scenario includes two case studies for the medium size (A1) and large size wineries (A2) for bottles that are commercialized in local small stores, restaurants or during wine tastings. In both case studies, inverse logistics is employed and trucks that are employed to carry the products to the stores from the winery is also used to collect the returned empty bottles and bring them back to the winery. Figure 5 summarises this scenario.



Figure 5 Large and medium size case study scheme

Scenario B: Large retail: Small and medium size wineries

This scenario includes two case studies for a small (B2) and a medium size (B1) wineries wine bottles that are commercialized in large retail stores. In both case studies, there is a warehouse where bottles are stored after and before being washed. For the medium size winery, the logistics includes the employment of a social cooperative to collect wine bottles from the stores and transport them to the warehouse, using electric scooters. In the small size winery case study, inverse logistics is employed and trucks that are employed to carry the products to the stores from the warehouse is also used to collect the returned empty bottles and bring them back to the warehouse. Figure 6 summarises this scenario.

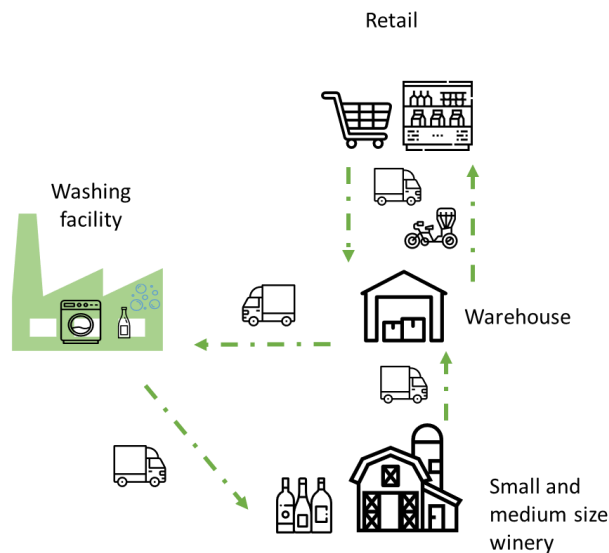


Figure 6 Large retail case study scheme

Scenario C: Small retail and tasting: small size wineries

This scenario includes two case studies for 2 small size wineries wine bottles that are commercialized in local small stores or during wine tastes. In both case studies, inverse logistics is employed and trucks that are employed to carry the products to the stores from the winery is also used to collect the returned empty bottles and bring them back to the winery. Figure 7 summarises this scenario.



Figure 7 Small retail and small wineries case study scheme

Scenario D: HORECA and integrated washing facilities

This scenario includes a case study for small size winery that has a washing facility integrated. The washing process is different from the one employed by Infinity, as it uses chemical products. This winery delivers wine bottles to local restaurants and, using inverse logistics, carries back the empty bottles to the winery for washing. Figure 8 summarises this scenario.

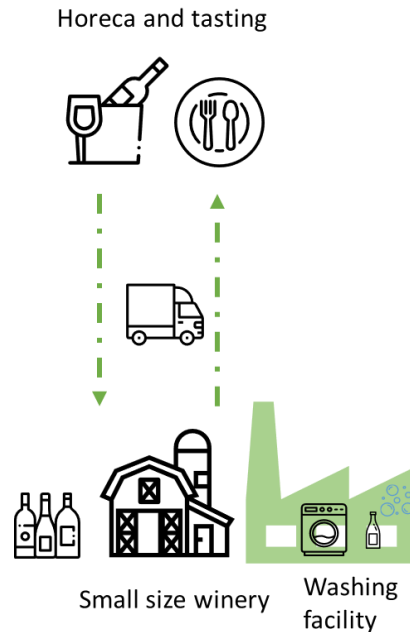


Figure 8 Small size winery and integrated washing case study scheme

For all scenarios, unless stated, the environmental and economic assessment has been carried out considering that bottles are transported in wooden pallets (720 bottles/pallet) and wrapped with plastic film. However, For the economic assessment, 2 additional packaging possibilities have been evaluated as an alternative packaging: reusable plastic box and reusable container. The results of the environmental and economic assessment are reported in section 4.

Scenario E: Large retail and waste management system: large and medium size wineries

This scenario includes two case studies for a medium (E1) and large size (E2) winery wine bottles that are commercialized in a supermarket. Consumers, once the wine is consumed and the bottle is empty, are responsible to bring the bottles to a waste collection point in their town. Bottles are collected there and then they are shipped to the washing facility. Figure 9 summarises this scenario.

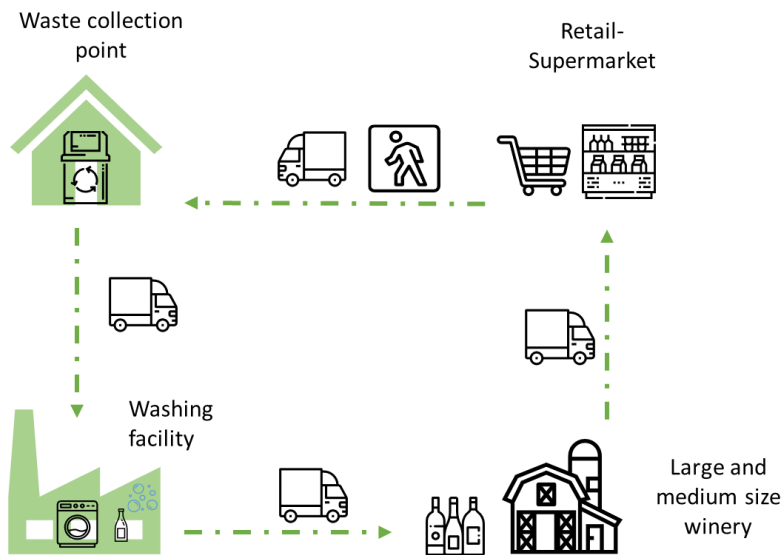


Figure 9 Large and medium size wineries for Retail and waste collection point case study scheme

3.2 Inventory Data

3.2.2. Environmental assessment general data

The following tables report the data used to perform the environmental assessment. It should be noted that the Functional unit for the assessment is the washing of 500 bottles, as it is the washing batch capacity. However, for some items, the values are reported for 1 bottle. The reusable bottle is compared to a single use bottle produced in Spain. Table 2 reports the consumptions during the washing that will be analysed under an environmental perspective at Infinity and at the integrated washing facility.

Table 2 Consumptions during the washing

Consumption	Unit	INFINITY	INTEGRATED WASHING FACILITY
Rinsing water from network	Litres/bottle	0,04744	1,11
Detergent	Kg/bottle	0,00073	-
Brighter	Litres/bottle	0,00007	-
Diesel for heating up	Litres/bottle	0,00214	0,00214*
Diesel during the washing	Litres/bottle	0,00428	0,00428*
Electricity	kWh/bottle	0,03598	0,0102
Salt	Kg/bottle	0,0000001	-
Resin for decalcifier	Kg/bottle	0,0000008	-
NaOH	Kg/bottle	0	0,022

*Data assumed using INFINITY values

Table 3 reports the distances of bottles shipments that have been considered for each case study.

Table 3 Distances for the bottles collection and between the winery and washing facility

CASE STUDIES	Distances (km)	Comments
A1. MEDIUM SIZE WINERY	8,3+384	Distribution, collection and transport to INFINITY
A2. LARGE WINERY		Distribution, collection and transport to INFINITY
B1. MEDIUM SIZE WINERY AND RETAIL	64+34+10+480	Distribution to the stores, collection and transport to INFINITY
B2. SMALL SIZE WINERY AND RETAIL	37+560	Distribution to the stores, collection and transport to INFINITY
C1. SMALL WINERY AND TASTE	95,6+530	Distribution, collection and transport to INFINITY
C2. SMALL WINERY AND LOCAL STORES	30+622	Distribution, collection and transport to INFINITY
D1. SMALL WINERY AND INTEGRATED WASHING	30	Average distance of the distribution and collection of wine bottles
E1. MEDIUM SIZE WINERY+RETAIL	150+50+3+498	Distribution to the stores, distance to waste collection point and transport to INFINITY
E2. LARGE WINERY+RETAIL	35+50+3+498	Distribution to the stores, distance to waste collection point and transport to INFINITY

The environmental assessment has been carried out considering different alternatives:

- Only 1 washing is required, thus 8 reuses of the wine bottle are possible
- 2 washings are required per cycle of reuse, thus 3 reuses of the wine bottle are possible
- 3 washings are required per cycle of reuse, thus 2 reuses of the wine bottle are possible

These alternatives respond to the fact that during the pilot test more than one washing was required since empty wine bottles were stored for a long time before being washed.

Additionally, the environmental assessment includes the evaluation in the current case, using the current distances between the wineries and the washing facilities, and an optimized scenario where the distances is reduced up to 60 km.

As it can be seen from the different scenarios there are variables that have an important role when calculating the economic sustainability in the reuse bottle process. The information gathered for this study is collaboration from the actors involved in the Life+ reWINE Project.

4 Results & Discussion

4.1 Environmental assessment

This section includes the environmental assessment for each case study and a summary for each scenario. The environmental assessment includes a sensitivity analysis where different alternatives are studied to understand the contribution of the distance of the wineries to the washing facilities and the contribution of the number of washings required per cycle of reuse.

4.2.1. Evaluation of MEDIUM SIZE WINERY -HORECA (A1)

Table 4 reports the LCA results for the medium size winery -Horeca case study considering 8 reuses (7 washes) for 500 wine bottles.

Table 4 LCA results for 500 wine bottles and 8 reuses for medium size winery-Horeca

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,51E-04	3,48E-05	0,00E+00	1,86E-03	1,31E-04	1,86E-03	1,17E-05	1,04E-06	1,15E-03
Abiotic depletion (fossil fuels)	MJ	3,94E+03	1,01E+02	0,00E+00	5,64E+03	3,16E+03	5,64E+03	2,49E+02	3,13E+01	6,38E+03
Global warming (GWP100a)	kg CO2 eq	2,99E+02	6,94E+00	0,00E+00	3,82E+02	2,36E+02	3,82E+02	1,73E+01	9,56E-01	4,67E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	4,03E-05	1,21E-06	0,00E+00	6,37E-05	3,41E-05	6,37E-05	3,16E-06	3,83E-07	6,81E-05
Human toxicity	kg 1,4-DB eq	1,85E+02	2,10E+00	0,00E+00	1,50E+02	2,09E+01	1,50E+02	2,97E+00	1,98E-01	2,36E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,90E+01	8,43E-01	0,00E+00	5,55E+01	3,91E+01	5,55E+01	5,67E-01	8,95E-02	1,22E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,29E+05	2,39E+03	0,00E+00	1,53E+05	2,75E+04	1,53E+05	1,75E+03	2,56E+02	4,81E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	3,12E-01	1,09E-02	0,00E+00	6,65E-01	1,35E+01	6,65E-01	6,93E-03	9,93E-04	2,45E+00
Photochemical oxidation	kg C2H4 eq	6,23E-02	1,28E-03	0,00E+00	8,23E-02	4,03E-02	8,23E-02	3,24E-03	2,69E-04	9,63E-02
Acidification	kg SO2 eq	1,65E+00	3,29E-02	0,00E+00	1,82E+00	6,84E-01	1,82E+00	8,22E-02	7,10E-03	2,38E+00
Eutrophication	kg PO4--- eq	2,33E-01	8,31E-03	0,00E+00	4,79E-01	9,36E-02	4,79E-01	1,76E-02	1,57E-03	4,10E-01

Table 5 reports the difference of the LCA results for the medium size winery-Horeca case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 5 Difference in the LCA results for a single use and a reusable bottle for the medium size winery

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	4,98E-05	9,96E-05	1,49E-04	1,99E-04	2,49E-04	2,99E-04	3,48E-04	6,97E-07
Abiotic depletion (fossil fuels)	MJ	0,00E+00	2,26E+03	4,51E+03	6,77E+03	9,03E+03	1,13E+04	1,35E+04	1,58E+04	3,16E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,82E+02	3,63E+02	5,45E+02	7,27E+02	9,09E+02	1,09E+03	1,27E+03	2,54
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	2,20E-05	4,39E-05	6,59E-05	8,78E-05	1,10E-04	1,32E-04	1,54E-04	3,07E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,44E+02	2,89E+02	4,33E+02	5,77E+02	7,22E+02	8,66E+02	1,01E+03	2,02E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	7,90E+01	1,58E+02	2,37E+02	3,16E+02	3,95E+02	4,74E+02	5,53E+02	1,11E+00
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	3,86E+05	7,72E+05	1,16E+06	1,54E+06	1,93E+06	2,32E+06	2,70E+06	5,40E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,79E+00	-3,58E+00	-5,37E+00	-7,16E+00	-8,95E+00	-1,07E+01	-1,25E+01	-2,51E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	3,78E-02	7,56E-02	1,13E-01	1,51E-01	1,89E-01	2,27E-01	2,65E-01	5,29E-04
Acidification	kg SO2 eq	0,00E+00	1,15E+00	2,30E+00	3,45E+00	4,60E+00	5,75E+00	6,90E+00	8,05E+00	1,61E-02
Eutrophication	kg PO4--- eq	0,00E+00	1,10E-01	2,20E-01	3,30E-01	4,40E-01	5,50E-01	6,60E-01	7,70E-01	1,54E-03

Figure 10 shows graphically the evolution of the savings in CO₂ equivalent emissions at each reuse cycle.

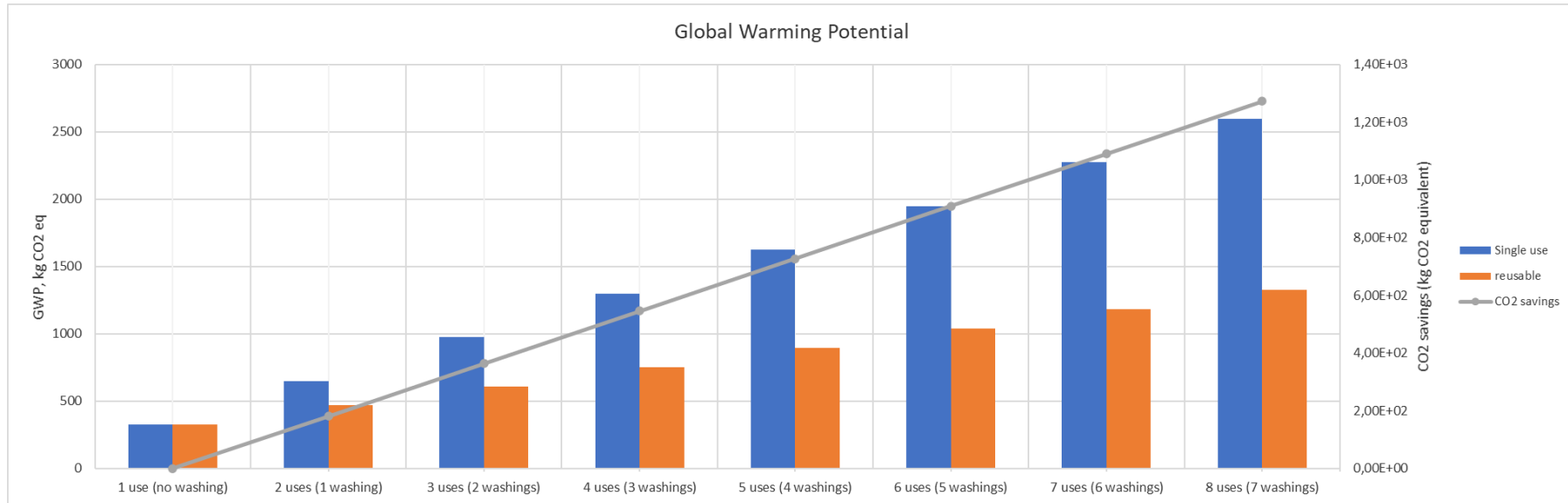


Figure 10 GWP savings evolution for medium size winery- Horeca

In case more than one washing per cycle is required, the Table 6 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case (REAL) and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 6 GWP savings considering distance and number of washings per cycle for medium size Horeca

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	6,97E-07	6,38E-06	1,86E-07	2,62E-06	4,94E-08	1,67E-06
Abiotic depletion (fossil fuels)	MJ	3,16E+01	4,81E+01	1,08E+01	1,79E+01	5,42E+00	1,01E+01
Global warming (GWP100a)	kg CO2 eq	2,54E+00	3,68E+00	8,88E-01	1,37E+00	4,57E-01	7,81E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	3,07E-07	5,04E-07	1,03E-07	1,87E-07	4,89E-08	1,05E-07
Human toxicity	kg 1,4-DB eq	2,02E+00	2,36E+00	8,48E-01	9,95E-01	5,53E-01	6,51E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	1,11E+00	1,24E+00	4,41E-01	5,00E-01	2,71E-01	3,11E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	5,40E+03	5,79E+03	2,29E+03	2,46E+03	1,51E+03	1,62E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,51E-02	-2,33E-02	-2,23E-02	-2,16E-02	-2,26E-02	-2,21E-02
Photochemical oxidation	kg C2H4 eq	5,29E-04	7,38E-04	1,92E-04	2,82E-04	1,05E-04	1,65E-04
Acidification	kg SO2 eq	1,61E-02	2,15E-02	6,32E-03	8,62E-03	3,82E-03	5,35E-03
Eutrophication	kg PO4--- eq	1,54E-03	2,90E-03	5,80E-04	1,16E-03	3,20E-03	5,47E-03

As it can be notice, savings considering an optimal distance, could be, as a general rule, 1.5 times higher than for the current distance.

4.2.2. Evaluation of the large winery scenario-HORECA (A2)

Table 7 reports the LCA results for the large winery-Horeca case study considering 8 reuses (7 washes) for 500 wine bottles.

Table 7 LCA results for 500 wine bottles and 8 reuses for large winery-HORECA

		Production	Transport to winery	Distribution	Transport to washing	Washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,02E-04	3,48E-05	0,00E+00	1,93E-03	1,31E-04	1,93E-03	1,07E-05	9,46E-07	1,12E-03
Abiotic depletion (fossil fuels)	MJ	3,59E+03	1,01E+02	0,00E+00	5,84E+03	3,16E+03	5,84E+03	2,26E+02	2,86E+01	6,06E+03
Global warming (GWP100a)	kg CO2 eq	2,73E+02	6,94E+00	0,00E+00	3,96E+02	2,36E+02	3,96E+02	1,58E+01	8,71E-01	4,43E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	3,67E-05	1,21E-06	0,00E+00	6,62E-05	3,41E-05	6,62E-05	2,88E-06	3,49E-07	6,49E-05
Human toxicity	kg 1,4-DB eq	1,69E+02	2,10E+00	0,00E+00	1,54E+02	2,09E+01	1,54E+02	2,70E+00	1,80E-01	2,21E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,02E+01	8,43E-01	0,00E+00	5,72E+01	3,91E+01	5,72E+01	5,17E-01	8,15E-02	1,14E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	3,91E+05	2,39E+03	0,00E+00	1,58E+05	5,80E+05	1,58E+05	1,59E+03	2,33E+02	5,23E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	2,84E-01	1,09E-02	0,00E+00	6,87E-01	1,41E+01	6,87E-01	6,32E-03	9,05E-04	2,52E+00
Photochemical oxidation	kg C2H4 eq	5,68E-02	1,28E-03	0,00E+00	8,49E-02	1,27E-01	8,49E-02	2,95E-03	2,45E-04	1,04E-01
Acidification	kg SO2 eq	1,50E+00	3,29E-02	0,00E+00	1,88E+00	3,00E+00	1,88E+00	7,49E-02	6,47E-03	2,58E+00
Eutrophication	kg PO4--- eq	2,12E-01	8,31E-03	0,00E+00	4,95E-01	9,36E-02	4,95E-01	1,60E-02	1,43E-03	3,93E-01

Table 8 reports the difference of the LCA results for the large winery-Horeca case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 8 Difference in the LCA results for a single use and a reusable bottle for large winery

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	-2,05E-05	-4,10E-05	-6,14E-05	-8,19E-05	-1,02E-04	-1,23E-04	-1,43E-04	-2,87E-07
Abiotic depletion (fossil fuels)	MJ	0,00E+00	1,82E+03	3,65E+03	5,47E+03	7,29E+03	9,12E+03	1,09E+04	1,28E+04	2,55E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,49E+02	2,99E+02	4,48E+02	5,98E+02	7,47E+02	8,97E+02	1,05E+03	2,09E+00
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	1,74E-05	3,47E-05	5,21E-05	6,94E-05	8,68E-05	1,04E-04	1,22E-04	2,43E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,26E+02	2,53E+02	3,79E+02	5,06E+02	6,32E+02	7,58E+02	8,85E+02	1,77E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	6,97E+01	1,39E+02	2,09E+02	2,79E+02	3,49E+02	4,18E+02	4,88E+02	9,76E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	2,67E+05	5,35E+05	8,02E+05	1,07E+06	1,34E+06	1,60E+06	1,87E+06	3,74E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,91E+00	-3,83E+00	-5,74E+00	-7,66E+00	-9,57E+00	-1,15E+01	-1,34E+01	-2,68E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	1,88E-02	3,77E-02	5,65E-02	7,54E-02	9,42E-02	1,13E-01	1,32E-01	2,64E-04
Acidification	kg SO2 eq	0,00E+00	6,46E-01	1,29E+00	1,94E+00	2,58E+00	3,23E+00	3,88E+00	4,52E+00	9,04E-03
Eutrophication	kg PO4--- eq	0,00E+00	8,28E-02	1,66E-01	2,48E-01	3,31E-01	4,14E-01	4,97E-01	5,80E-01	1,16E-03

Figure 11 shows graphically the evolution of the savings in CO2 equivalent emissions at each reuse cycle.

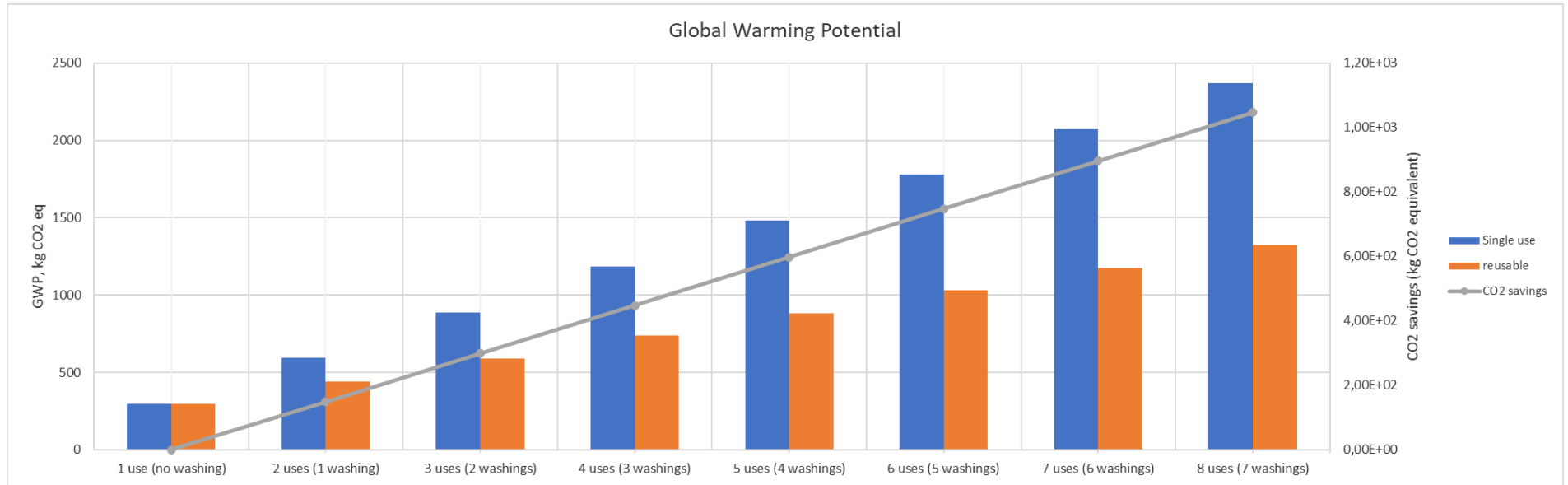


Figure 11 GWP savings evolution for large winery

In the case more than one washing per cycle is required, the Table 9 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case (REAL) and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 9 GWP savings considering distance and number of washings per cycle for large winery Horeca

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	-2,87E-07	5,82E-06	-2,35E-07	2,38E-06	-1,16E-07	7,56E-07
Abiotic depletion (fossil fuels)	MJ	2,55E+01	4,33E+01	8,23E+00	1,58E+01	1,84E+00	4,38E+00
Global warming (GWP100a)	kg CO2 eq	2,09E+00	3,31E+00	6,95E-01	1,22E+00	1,64E-01	3,38E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	2,43E-07	4,55E-07	7,50E-08	1,66E-07	1,53E-08	4,55E-08
Human toxicity	kg 1,4-DB eq	1,77E+00	2,14E+00	7,40E-01	8,98E-01	2,41E-01	2,93E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,76E-01	1,12E+00	3,85E-01	4,48E-01	1,17E-01	1,38E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	3,74E+03	5,27E+03	1,11E+03	2,23E+03	2,03E+02	7,37E+02
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,68E-02	-2,36E-02	-2,36E-02	-2,17E-02	-1,19E-02	-1,11E-02
Photochemical oxidation	kg C2H4 eq	2,64E-04	6,61E-04	4,22E-06	2,49E-04	-3,49E-05	7,15E-05
Acidification	kg SO2 eq	9,04E-03	1,94E-02	1,30E-03	7,75E-03	-4,24E-04	2,39E-03
Eutrophication	kg PO4--- eq	1,16E-03	2,62E-03	4,17E-04	1,04E-03	1,12E-04	3,20E-04

4.2.3. Evaluation of a scenario: Medium size winery and retail (B1)

Table 10 reports the LCA results for the medium size winery and retail case study considering 8 reuses (7 washes) for 500 wine bottles.

Table 10 LCA results for 500 wine bottles and 8 reuses for medium size winery and retail

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,02E-04	3,17E-05	0,00E+00	2,07E-03	1,31E-04	1,95E-03	1,07E-05	9,46E-07	1,14E-03
Abiotic depletion (fossil fuels)	MJ	3,59E+03	9,22E+01	0,00E+00	6,25E+03	3,16E+03	5,90E+03	2,26E+02	2,86E+01	6,12E+03
Global warming (GWP100a)	kg CO2 eq	2,73E+02	6,32E+00	0,00E+00	4,24E+02	2,36E+02	4,00E+02	1,58E+01	8,71E-01	4,47E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	3,67E-05	1,10E-06	0,00E+00	7,10E-05	3,41E-05	6,69E-05	2,88E-06	3,49E-07	6,56E-05
Human toxicity	kg 1,4-DB eq	1,69E+02	1,91E+00	0,00E+00	1,63E+02	2,09E+01	1,56E+02	2,70E+00	1,80E-01	2,22E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,02E+01	7,68E-01	0,00E+00	6,06E+01	3,91E+01	5,77E+01	5,17E-01	8,15E-02	1,14E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	3,91E+05	2,17E+03	0,00E+00	1,67E+05	2,75E+04	1,59E+05	1,59E+03	2,33E+02	4,46E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	2,84E-01	9,89E-03	0,00E+00	7,31E-01	1,35E+01	6,93E-01	6,32E-03	9,05E-04	2,44E+00
Photochemical oxidation	kg C2H4 eq	5,68E-02	1,17E-03	0,00E+00	9,01E-02	4,03E-02	8,56E-02	2,95E-03	2,45E-04	9,20E-02
Acidification	kg SO2 eq	1,50E+00	3,00E-02	0,00E+00	2,02E+00	6,84E-01	1,90E+00	7,49E-02	6,47E-03	2,27E+00
Eutrophication	kg PO4--- eq	2,12E-01	7,57E-03	0,00E+00	5,29E-01	9,36E-02	5,00E-01	1,60E-02	1,43E-03	3,97E-01

Table 11 reports the difference of the LCA results for the medium size winery and retail case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 11 Difference in the LCA results for a single use and a reusable bottle for the medium size winery and retail

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	-4,66E-05	-9,31E-05	-1,40E-04	-1,86E-04	-2,33E-04	-2,79E-04	-3,26E-04	-6,52E-07
Abiotic depletion (fossil fuels)	MJ	0,00E+00	1,75E+03	3,49E+03	5,24E+03	6,99E+03	8,74E+03	1,05E+04	1,22E+04	2,45E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,44E+02	2,89E+02	4,33E+02	5,77E+02	7,21E+02	8,66E+02	1,01E+03	2,02
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	1,65E-05	3,29E-05	4,94E-05	6,58E-05	8,23E-05	9,87E-05	1,15E-04	2,30E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,25E+02	2,50E+02	3,74E+02	4,99E+02	6,24E+02	7,49E+02	8,74E+02	1,75E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	6,91E+01	1,38E+02	2,07E+02	2,76E+02	3,45E+02	4,14E+02	4,83E+02	9,67E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	3,45E+05	6,89E+05	1,03E+06	1,38E+06	1,72E+06	2,07E+06	2,41E+06	4,82E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,83E+00	-3,67E+00	-5,50E+00	-7,33E+00	-9,16E+00	-1,10E+01	-1,28E+01	-2,57E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	3,03E-02	6,05E-02	9,08E-02	1,21E-01	1,51E-01	1,82E-01	2,12E-01	4,24E-04
Acidification	kg SO2 eq	0,00E+00	9,53E-01	1,91E+00	2,86E+00	3,81E+00	4,76E+00	5,72E+00	6,67E+00	1,33E-02
Eutrophication	kg PO4--- eq	0,00E+00	7,66E-02	1,53E-01	2,30E-01	3,06E-01	3,83E-01	4,59E-01	5,36E-01	1,07E-03

Figure 12 shows graphically the evolution of the savings in CO2 equivalent emissions at each reuse cycle.

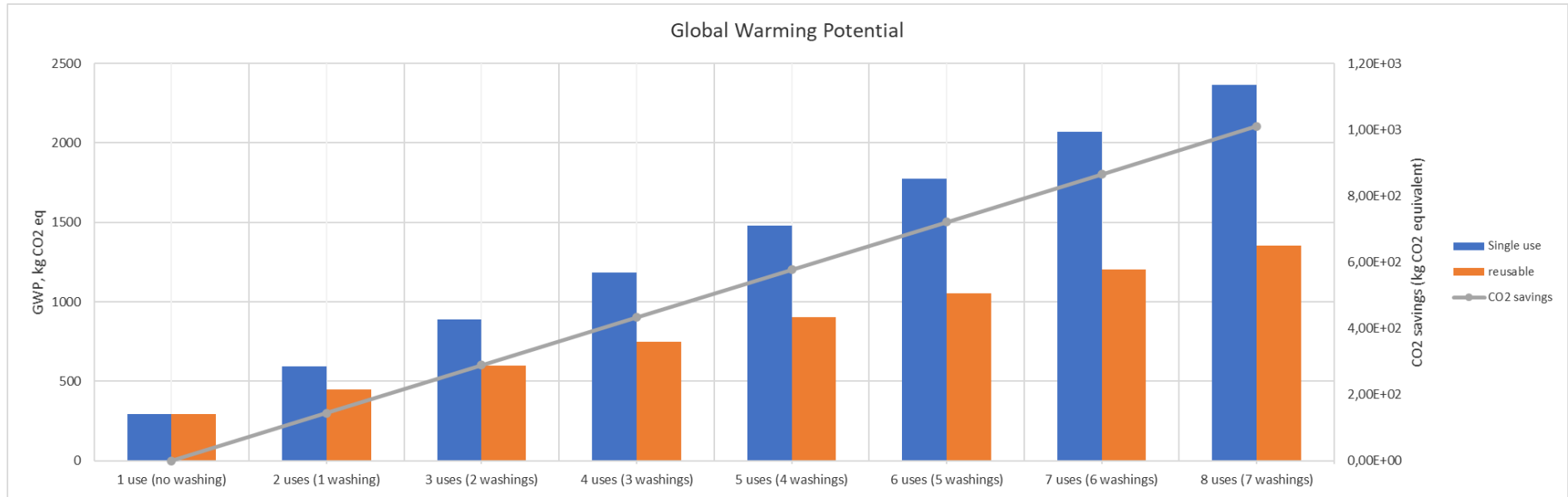


Figure 12 GWP savings evolution for medium size winery and retail

In the case more than one washing per cycle is required, the Table 12 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case (REAL) and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 12 GWP savings considering distance and number of washings per cycle for a medium size winery and retail

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	-6,52E-07	1,12E-06	-3,92E-07	3,67E-07	-5,04E-07	8,50E-08
Abiotic depletion (fossil fuels)	MJ	2,45E+01	2,96E+01	7,78E+00	9,98E+00	5,07E+00	2,42E+00
Global warming (GWP100a)	kg CO2 eq	2,02E+00	2,37E+00	6,64E-01	8,15E-01	4,61E-01	2,04E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	2,30E-07	2,92E-07	6,96E-08	9,59E-08	4,04E-08	2,22E-08
Human toxicity	kg 1,4-DB eq	1,75E+00	1,85E+00	7,31E-01	7,77E-01	7,13E-01	2,53E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,67E-01	1,01E+00	3,81E-01	3,99E-01	3,47E-01	1,22E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,82E+03	4,94E+03	2,04E+03	2,10E+03	2,02E+03	6,91E+02
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,57E-02	-2,51E-02	-2,26E-02	-2,23E-02	-3,42E-02	-1,13E-02
Photochemical oxidation	kg C2H4 eq	4,24E-04	4,89E-04	1,47E-04	1,75E-04	1,13E-04	4,68E-05
Acidification	kg SO2 eq	1,33E-02	1,50E-02	5,13E-03	5,85E-03	4,54E-03	1,75E-03
Eutrophication	kg PO4--- eq	1,07E-03	1,49E-03	3,79E-04	5,60E-04	2,99E-04	1,60E-04

4.2.4. Evaluation of the small size winery and retail scenario (B2)

Table 13 reports the LCA results for the small size winery and retail case study considering 8 reuses (7 washes) for 500 wine bottles.

Table 13 LCA results for 500 wine bottles and 8 reuses for small size winery and retail

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,51E-04	3,48E-05	0,00E+00	2,75E-03	1,31E-04	1,82E-03	1,17E-05	1,04E-06	1,27E-03
Abiotic depletion (fossil fuels)	MJ	3,94E+03	1,01E+02	0,00E+00	8,25E+03	3,16E+03	5,53E+03	2,49E+02	3,13E+01	6,74E+03
Global warming (GWP100a)	kg CO2 eq	2,99E+02	6,94E+00	0,00E+00	5,61E+02	2,36E+02	3,75E+02	1,73E+01	9,56E-01	4,92E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	4,03E-05	1,21E-06	0,00E+00	9,48E-05	3,41E-05	6,25E-05	3,16E-06	3,83E-07	7,24E-05
Human toxicity	kg 1,4-DB eq	1,85E+02	2,10E+00	0,00E+00	2,04E+02	2,09E+01	1,48E+02	2,97E+00	1,98E-01	2,44E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,90E+01	8,43E-01	0,00E+00	7,73E+01	3,91E+01	5,46E+01	5,67E-01	8,95E-02	1,25E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,29E+05	2,39E+03	0,00E+00	2,14E+05	2,75E+04	1,50E+05	1,75E+03	2,56E+02	4,90E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	3,12E-01	1,09E-02	0,00E+00	9,45E-01	1,35E+01	6,54E-01	6,93E-03	9,93E-04	2,49E+00
Photochemical oxidation	kg C2H4 eq	6,23E-02	1,28E-03	0,00E+00	1,15E-01	4,03E-02	8,09E-02	3,24E-03	2,69E-04	1,01E-01
Acidification	kg SO2 eq	1,65E+00	3,29E-02	0,00E+00	2,66E+00	6,84E-01	1,78E+00	8,22E-02	7,10E-03	2,50E+00
Eutrophication	kg PO4--- eq	2,33E-01	8,31E-03	0,00E+00	6,93E-01	9,36E-02	4,70E-01	1,76E-02	1,57E-03	4,40E-01

Table 14 reports the difference of the LCA results for the small size winery and retail case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 14 Difference in the LCA results for a single use and a reusable bottle for small size winery and retail

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	-7,33E-05	-1,47E-04	-2,20E-04	-2,93E-04	-3,66E-04	-4,40E-04	-5,13E-04	-1,03E-06
Abiotic depletion (fossil fuels)	MJ	0,00E+00	1,90E+03	3,80E+03	5,70E+03	7,60E+03	9,50E+03	1,14E+04	1,33E+04	2,66E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,57E+02	3,14E+02	4,72E+02	6,29E+02	7,86E+02	9,43E+02	1,10E+03	2,20
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	1,77E-05	3,54E-05	5,31E-05	7,08E-05	8,84E-05	1,06E-04	1,24E-04	2,48E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,37E+02	2,74E+02	4,11E+02	5,48E+02	6,85E+02	8,21E+02	9,58E+02	1,92E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	7,61E+01	1,52E+02	2,28E+02	3,04E+02	3,80E+02	4,56E+02	5,32E+02	1,06E+00
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	3,78E+05	7,55E+05	1,13E+06	1,51E+06	1,89E+06	2,27E+06	2,64E+06	5,29E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,83E+00	-3,66E+00	-5,48E+00	-7,31E+00	-9,14E+00	-1,10E+01	-1,28E+01	-2,56E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	3,33E-02	6,66E-02	9,99E-02	1,33E-01	1,67E-01	2,00E-01	2,33E-01	4,66E-04
Acidification	kg SO2 eq	0,00E+00	1,03E+00	2,07E+00	3,10E+00	4,14E+00	5,17E+00	6,21E+00	7,24E+00	1,45E-02
Eutrophication	kg PO4--- eq	0,00E+00	8,06E-02	1,61E-01	2,42E-01	3,22E-01	4,03E-01	4,84E-01	5,64E-01	1,13E-03

Figure 13 shows graphically the evolution of the savings in CO2 equivalent emissions at each reuse cycle.

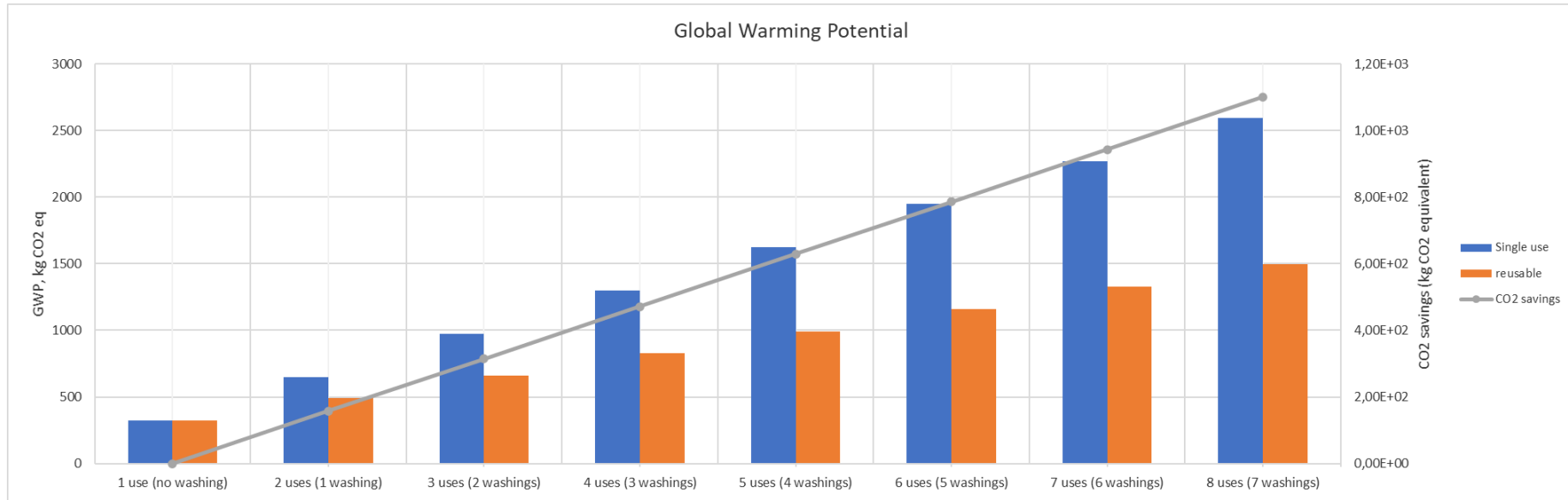


Figure 13 GWP savings evolution for Casa Ametller

In the case more than one washing per cycle is required, the Table 15 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case (REAL) and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 15 GWP savings considering distance and number of washings per cycle for small size winery and retail

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	-1,03E-06	5,50E-06	-5,52E-07	2,25E-06	-6,64E-07	2,13E-06
Abiotic depletion (fossil fuels)	MJ	2,66E+01	4,56E+01	8,69E+00	1,68E+01	5,98E+00	1,41E+01
Global warming (GWP100a)	kg CO2 eq	2,20E+00	3,50E+00	7,41E-01	1,30E+00	5,39E-01	1,10E+00
Ozone layer depletion (ODP)	kg CFC-11 eq	2,48E-07	4,74E-07	7,69E-08	1,74E-07	4,78E-08	1,45E-07
Human toxicity	kg 1,4-DB eq	1,92E+00	2,31E+00	8,04E-01	9,72E-01	7,86E-01	9,54E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	1,06E+00	1,22E+00	4,23E-01	4,91E-01	3,89E-01	4,57E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	5,29E+03	5,73E+03	2,24E+03	2,43E+03	2,22E+03	2,41E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,56E-02	-2,36E-02	-2,26E-02	-2,17E-02	-3,41E-02	-3,33E-02
Photochemical oxidation	kg C2H4 eq	4,66E-04	7,06E-04	1,65E-04	2,68E-04	1,31E-04	2,34E-04
Acidification	kg SO2 eq	1,45E-02	2,06E-02	5,62E-03	8,26E-03	5,03E-03	7,67E-03
Eutrophication	kg PO4--- eq	1,13E-03	2,69E-03	4,03E-04	1,07E-03	3,23E-04	9,91E-04

4.2.5. Evaluation of small size winery and tasting case study (C1)

Table 16 reports the LCA results for the small size winery and tasting case study considering 8 reuses (7 washes) for 500 wine bottles

Table 16 LCA results for 500 wine bottles and 8 reuses for small size winery

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,51E-04	3,48E-05	0,00E+00	2,88E-03	1,31E-04	2,46E-03	0,00E+00	0,00E+00	1,38E-03
Abiotic depletion (fossil fuels)	MJ	3,94E+03	1,01E+02	0,00E+00	8,61E+03	3,16E+03	7,39E+03	0,00E+00	0,00E+00	7,06E+03
Global warming (GWP100a)	kg CO2 eq	2,99E+02	6,94E+00	0,00E+00	5,86E+02	2,36E+02	5,02E+02	0,00E+00	0,00E+00	5,14E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	4,03E-05	1,21E-06	0,00E+00	9,92E-05	3,41E-05	8,47E-05	0,00E+00	0,00E+00	7,62E-05
Human toxicity	kg 1,4-DB eq	1,85E+02	2,10E+00	0,00E+00	2,12E+02	2,09E+01	1,87E+02	0,00E+00	0,00E+00	2,50E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,90E+01	8,43E-01	0,00E+00	8,03E+01	3,91E+01	7,01E+01	0,00E+00	0,00E+00	1,28E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,29E+05	2,39E+03	0,00E+00	2,23E+05	2,75E+04	1,94E+05	0,00E+00	0,00E+00	4,97E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	3,12E-01	1,09E-02	0,00E+00	9,84E-01	1,35E+01	8,53E-01	0,00E+00	0,00E+00	2,52E+00
Photochemical oxidation	kg C2H4 eq	6,23E-02	1,28E-03	0,00E+00	1,20E-01	4,03E-02	1,04E-01	0,00E+00	0,00E+00	1,05E-01
Acidification	kg SO2 eq	1,65E+00	3,29E-02	0,00E+00	2,78E+00	6,84E-01	2,39E+00	0,00E+00	0,00E+00	2,60E+00
Eutrophication	kg PO4--- eq	2,33E-01	8,31E-03	0,00E+00	7,23E-01	9,36E-02	6,23E-01	0,00E+00	0,00E+00	4,66E-01

Table 17 reports the difference of the LCA results for the small size winery case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 17 Difference in the LCA results for a single use and a reusable bottle for small size winery

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	-1,83E-04	-3,65E-04	-5,48E-04	-7,31E-04	-9,13E-04	-1,10E-03	-1,28E-03	-2,56E-06
Abiotic depletion (fossil fuels)	MJ	0,00E+00	1,58E+03	3,16E+03	4,74E+03	6,32E+03	7,91E+03	9,49E+03	1,11E+04	2,21E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,35E+02	2,71E+02	4,06E+02	5,42E+02	6,77E+02	8,12E+02	9,48E+02	1,90E+00
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	1,39E-05	2,78E-05	4,17E-05	5,56E-05	6,95E-05	8,34E-05	9,73E-05	1,95E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,30E+02	2,61E+02	3,91E+02	5,21E+02	6,52E+02	7,82E+02	9,12E+02	1,82E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	7,34E+01	1,47E+02	2,20E+02	2,94E+02	3,67E+02	4,41E+02	5,14E+02	1,03E+00
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	3,70E+05	7,40E+05	1,11E+06	1,48E+06	1,85E+06	2,22E+06	2,59E+06	5,18E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,86E+00	-3,72E+00	-5,59E+00	-7,45E+00	-9,31E+00	-1,12E+01	-1,30E+01	-2,61E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	2,93E-02	5,86E-02	8,79E-02	1,17E-01	1,46E-01	1,76E-01	2,05E-01	4,10E-04
Acidification	kg SO2 eq	0,00E+00	9,31E-01	1,86E+00	2,79E+00	3,72E+00	4,66E+00	5,59E+00	6,52E+00	1,30E-02
Eutrophication	kg PO4--- eq	0,00E+00	5,45E-02	1,09E-01	1,63E-01	2,18E-01	2,72E-01	3,27E-01	3,81E-01	7,63E-04

Figure 14 GWP savings evolution for shows graphically the evolution of the savings in CO2 equivalent emissions at each reuse cycle.

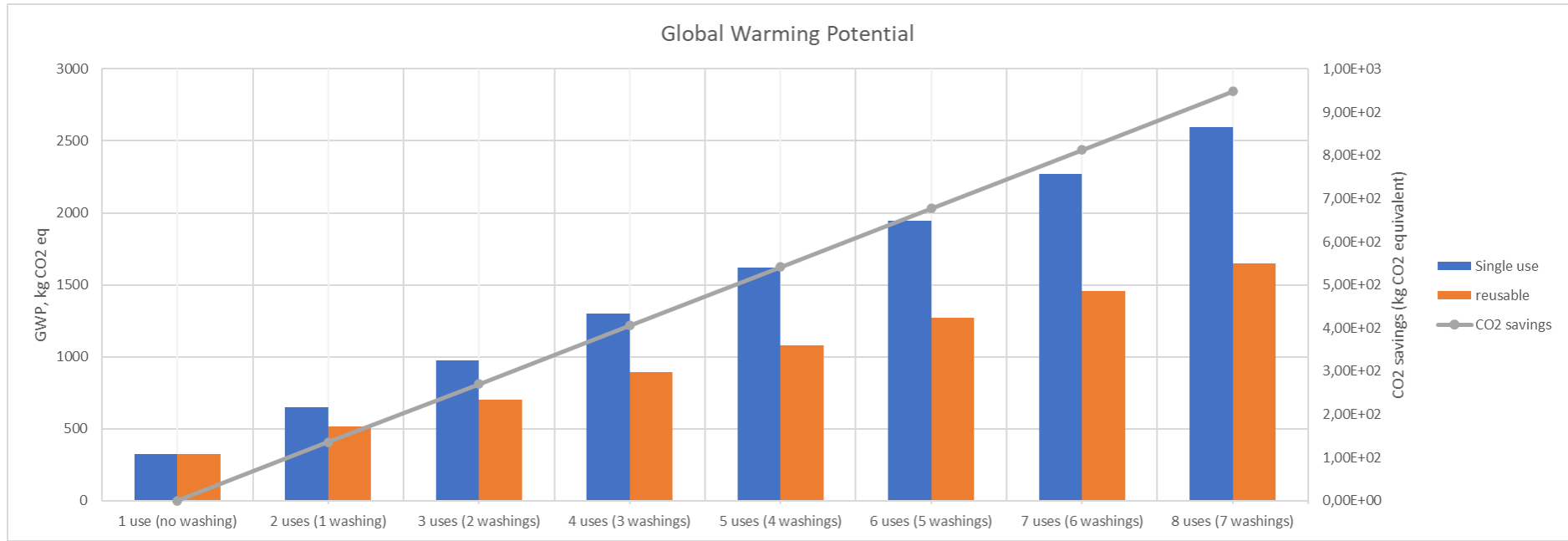


Figure 14 GWP savings evolution for small size winery

In the case more than one washing per cycle is required, the Table 18 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case (REAL) and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 18 GWP savings considering distance and number of washings per cycle for small size winery

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	-2,56E-06	5,69E-06	-1,21E-06	2,33E-06	-8,80E-07	1,48E-06
Abiotic depletion (fossil fuels)	MJ	2,21E+01	4,61E+01	6,78E+00	1,71E+01	2,71E+00	9,56E+00
Global warming (GWP100a)	kg CO2 eq	1,90E+00	3,54E+00	6,10E-01	1,31E+00	2,72E-01	7,41E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	1,95E-07	4,80E-07	5,42E-08	1,77E-07	1,67E-08	9,83E-08
Human toxicity	kg 1,4-DB eq	1,82E+00	2,32E+00	7,64E-01	9,77E-01	4,97E-01	6,39E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	1,03E+00	1,23E+00	4,07E-01	4,93E-01	2,49E-01	3,06E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	5,18E+03	5,75E+03	2,20E+03	2,44E+03	1,45E+03	1,61E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,61E-02	-2,35E-02	-2,28E-02	-2,17E-02	-2,29E-02	-2,22E-02
Photochemical oxidation	kg C2H4 eq	4,10E-04	7,13E-04	1,41E-04	2,71E-04	7,11E-05	1,58E-04
Acidification	kg SO2 eq	1,30E-02	2,08E-02	5,00E-03	8,34E-03	2,94E-03	5,17E-03
Eutrophication	kg PO4--- eq	7,63E-04	2,73E-03	2,47E-04	1,09E-03	1,11E-04	6,73E-04

4.2.6. Evaluation of small size winery and local stores case studies (C2)

Table 19 reports the LCA results for the small size winery and local stores case study considering 8 reuses (7 washes) for 500 wine bottles.

Table 19 LCA results for 500 wine bottles and 8 reuses for small size winery and local stores

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,51E-04	3,48E-05	0,00E+00	3,06E-03	1,31E-04	2,86E-03	0,00E+00	0,00E+00	1,46E-03
Abiotic depletion (fossil fuels)	MJ	3,94E+03	1,01E+02	0,00E+00	9,13E+03	3,16E+03	8,57E+03	0,00E+00	0,00E+00	7,30E+03
Global warming (GWP100a)	kg CO2 eq	2,99E+02	6,94E+00	0,00E+00	6,21E+02	2,36E+02	5,82E+02	0,00E+00	0,00E+00	5,30E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	4,03E-05	1,21E-06	0,00E+00	1,05E-04	3,41E-05	9,86E-05	0,00E+00	0,00E+00	7,90E-05
Human toxicity	kg 1,4-DB eq	1,85E+02	2,10E+00	0,00E+00	2,23E+02	2,09E+01	2,11E+02	0,00E+00	0,00E+00	2,55E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,90E+01	8,43E-01	0,00E+00	8,46E+01	3,91E+01	7,99E+01	0,00E+00	0,00E+00	1,30E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,29E+05	2,39E+03	0,00E+00	2,35E+05	2,75E+04	2,22E+05	0,00E+00	0,00E+00	5,03E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	3,12E-01	1,09E-02	0,00E+00	1,04E+00	1,35E+01	9,79E-01	0,00E+00	0,00E+00	2,55E+00
Photochemical oxidation	kg C2H4 eq	6,23E-02	1,28E-03	0,00E+00	1,26E-01	4,03E-02	1,19E-01	0,00E+00	0,00E+00	1,08E-01
Acidification	kg SO2 eq	1,65E+00	3,29E-02	0,00E+00	2,95E+00	6,84E-01	2,77E+00	0,00E+00	0,00E+00	2,68E+00
Eutrophication	kg PO4--- eq	2,33E-01	8,31E-03	0,00E+00	7,66E-01	9,36E-02	7,19E-01	0,00E+00	0,00E+00	4,86E-01

Table 20 reports the difference of the LCA results for the small size winery and local stores case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 20 Difference in the LCA results for a single use and a reusable bottle for small size winery and local stores

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	-2,66E-04	-5,32E-04	-7,98E-04	-1,06E-03	-1,33E-03	-1,60E-03	-1,86E-03	-3,72E-06
Abiotic depletion (fossil fuels)	MJ	0,00E+00	1,34E+03	2,68E+03	4,02E+03	5,36E+03	6,69E+03	8,03E+03	9,37E+03	1,87E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,19E+02	2,38E+02	3,56E+02	4,75E+02	5,94E+02	7,13E+02	8,32E+02	1,66E+00
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	1,10E-05	2,20E-05	3,30E-05	4,40E-05	5,51E-05	6,61E-05	7,71E-05	1,54E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,25E+02	2,51E+02	3,76E+02	5,01E+02	6,26E+02	7,52E+02	8,77E+02	1,75E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	7,14E+01	1,43E+02	2,14E+02	2,86E+02	3,57E+02	4,28E+02	5,00E+02	1,00E+00
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	3,64E+05	7,29E+05	1,09E+06	1,46E+06	1,82E+06	2,19E+06	2,55E+06	5,10E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,89E+00	-3,78E+00	-5,66E+00	-7,55E+00	-9,44E+00	-1,13E+01	-1,32E+01	-2,64E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	2,62E-02	5,24E-02	7,87E-02	1,05E-01	1,31E-01	1,57E-01	1,84E-01	3,67E-04
Acidification	kg SO2 eq	0,00E+00	8,52E-01	1,70E+00	2,56E+00	3,41E+00	4,26E+00	5,11E+00	5,97E+00	1,19E-02
Eutrophication	kg PO4--- eq	0,00E+00	3,46E-02	6,92E-02	1,04E-01	1,38E-01	1,73E-01	2,08E-01	2,42E-01	4,85E-04

Figure 15 shows graphically the evolution of the savings in CO2 equivalent emissions at each reuse cycle.

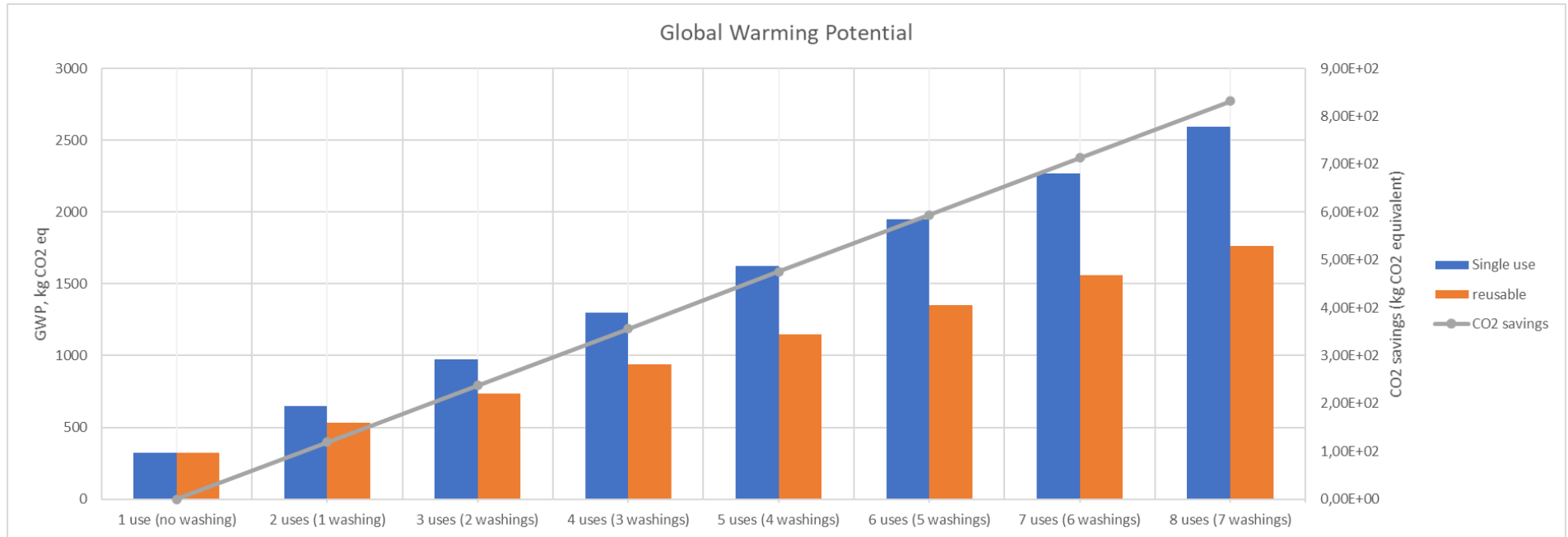


Figure 15 GWP savings evolution for small size winery and local stores

In the case more than one washing per cycle is required, the Table 21 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case (REAL) and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 21 GWP savings considering distance and number of washings per cycle for small size winery and local stores

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	-3,72E-06	6,14E-06	-1,71E-06	2,52E-06	-1,21E-06	1,60E-06
Abiotic depletion (fossil fuels)	MJ	1,87E+01	4,74E+01	5,32E+00	1,76E+01	1,74E+00	9,93E+00
Global warming (GWP100a)	kg CO2 eq	1,66E+00	3,63E+00	5,11E-01	1,35E+00	2,06E-01	7,67E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	1,54E-07	4,96E-07	3,69E-08	1,83E-07	5,12E-09	1,03E-07
Human toxicity	kg 1,4-DB eq	1,75E+00	2,35E+00	7,34E-01	9,88E-01	4,77E-01	6,47E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	1,00E+00	1,24E+00	3,95E-01	4,97E-01	2,41E-01	3,09E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	5,10E+03	5,78E+03	2,16E+03	2,45E+03	1,43E+03	1,30E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,64E-02	-2,34E-02	-2,29E-02	-2,16E-02	-2,30E-02	-2,21E-02
Photochemical oxidation	kg C2H4 eq	3,67E-04	7,29E-04	1,23E-04	2,78E-04	5,89E-05	1,62E-04
Acidification	kg SO2 eq	1,19E-02	2,12E-02	4,53E-03	8,52E-03	2,63E-03	5,29E-03
Eutrophication	kg PO4--- eq	4,85E-04	2,84E-03	1,27E-04	1,14E-03	3,14E-05	7,04E-04

4.2.7. Evaluation of Small winery and integrated washing scenario (D)

Table 22 reports the LCA results for the small winery and integrated washing case study considering 8 reuses (7 washes) for 500 wine bottles.

Table 22 LCA results for 500 wine bottles and 8 reuses for the small winery and integrated washing

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,51E-04	3,48E-05	0,00E+00	3,51E-04	5,02E-04	0,00E+00	0,00E+00	0,00E+00	7,21E-04
Abiotic depletion (fossil fuels)	MJ	3,94E+03	1,01E+02	0,00E+00	1,27E+03	3,29E+03	0,00E+00	0,00E+00	0,00E+00	4,97E+03
Global warming (GWP100a)	kg CO2 eq	2,99E+02	6,94E+00	0,00E+00	8,72E+01	2,50E+02	0,00E+00	0,00E+00	0,00E+00	3,73E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	4,03E-05	1,21E-06	0,00E+00	1,54E-05	8,20E-05	0,00E+00	0,00E+00	0,00E+00	5,89E-05
Human toxicity	kg 1,4-DB eq	1,85E+02	2,10E+00	0,00E+00	3,39E+01	6,31E+01	0,00E+00	0,00E+00	0,00E+00	2,04E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,90E+01	8,43E-01	0,00E+00	2,06E+01	4,85E+01	0,00E+00	0,00E+00	0,00E+00	1,10E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,29E+05	2,39E+03	0,00E+00	5,17E+04	1,37E+05	0,00E+00	0,00E+00	0,00E+00	4,61E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	3,12E-01	1,09E-02	0,00E+00	1,52E-01	3,55E-01	0,00E+00	0,00E+00	0,00E+00	4,03E-01
Photochemical oxidation	kg C2H4 eq	6,23E-02	1,28E-03	0,00E+00	3,51E-02	3,92E-02	0,00E+00	0,00E+00	0,00E+00	7,77E-02
Acidification	kg SO2 eq	1,65E+00	3,29E-02	0,00E+00	3,79E-01	8,04E-01	0,00E+00	0,00E+00	0,00E+00	1,94E+00
Eutrophication	kg PO4--- eq	2,33E-01	8,31E-03	0,00E+00	1,16E-01	3,12E-01	0,00E+00	0,00E+00	0,00E+00	3,21E-01

Table 23 reports the difference of the LCA results for the small winery and integrated washing case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 23 Difference in the LCA results for a single use and a reusable bottle for small winery and integrated washing

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	4,77E-04	9,54E-04	1,43E-03	1,91E-03	2,38E-03	2,86E-03	3,34E-03	6,68E-06
Abiotic depletion (fossil fuels)	MJ	0,00E+00	3,67E+03	7,33E+03	1,10E+04	1,47E+04	1,83E+04	2,20E+04	2,57E+04	5,13E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	2,76E+02	5,53E+02	8,29E+02	1,11E+03	1,38E+03	1,66E+03	1,93E+03	3,87
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	3,11E-05	6,22E-05	9,33E-05	1,24E-04	1,56E-04	1,87E-04	2,18E-04	4,35E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,76E+02	3,53E+02	5,29E+02	7,05E+02	8,82E+02	1,06E+03	1,23E+03	2,47E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	9,06E+01	1,81E+02	2,72E+02	3,63E+02	4,53E+02	5,44E+02	6,34E+02	1,27E+00
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	4,07E+05	8,13E+05	1,22E+06	1,63E+06	2,03E+06	2,44E+06	2,85E+06	5,69E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	2,58E-01	5,17E-01	7,75E-01	1,03E+00	1,29E+00	1,55E+00	1,81E+00	3,62E-03
Photochemical oxidation	kg C2H4 eq	0,00E+00	5,65E-02	1,13E-01	1,69E-01	2,26E-01	2,82E-01	3,39E-01	3,95E-01	7,91E-04
Acidification	kg SO2 eq	0,00E+00	1,60E+00	3,20E+00	4,79E+00	6,39E+00	7,99E+00	9,59E+00	1,12E+01	2,24E-02
Eutrophication	kg PO4--- eq	0,00E+00	1,99E-01	3,98E-01	5,97E-01	7,96E-01	9,95E-01	1,19E+00	1,39E+00	2,79E-03

Figure 16 shows graphically the evolution of the savings in CO2 equivalent emissions at each reuse cycle.

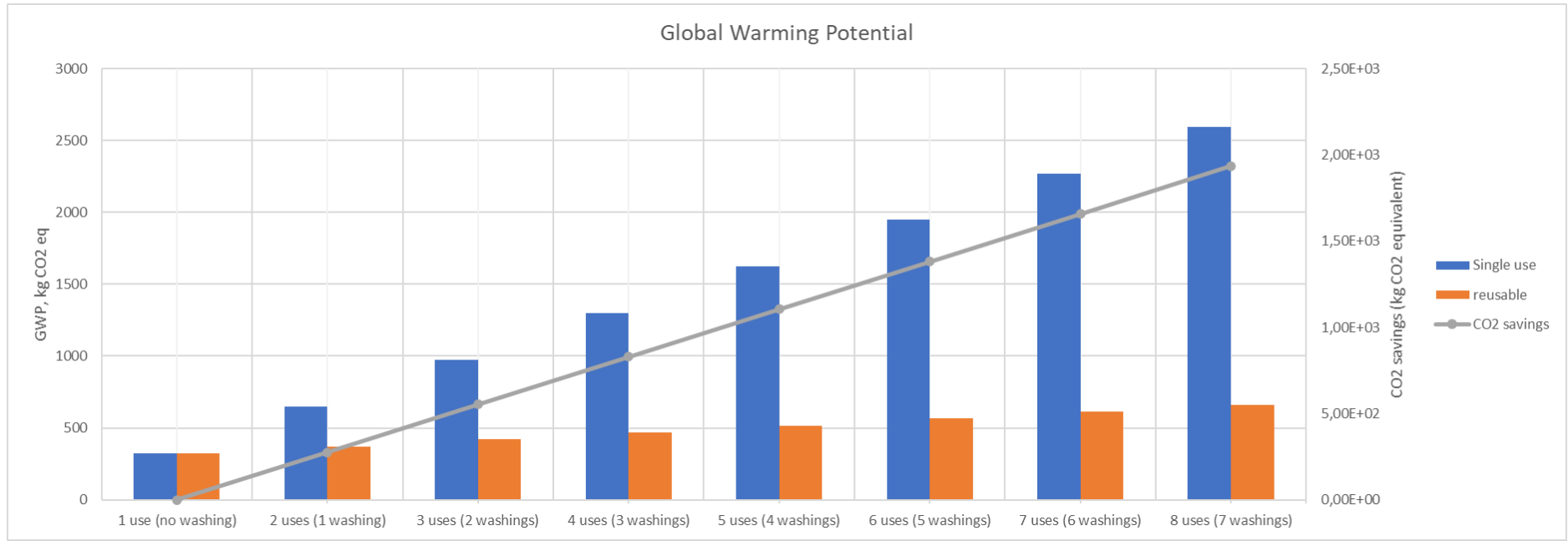


Figure 16 GWP savings evolution for small winery and integrated washing

4.2.8. Evaluation of medium size winery +retail+ waste collection point (E1)

Table 24 reports the LCA results for the medium size winery+ retail and waste collection point case study considering 8 reuses (7 washes) for 500 wine bottles

Table 24 LCA results for 500 wine bottles and 8 reuses for medium size winery and retail

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,51E-04	3,48E-05	0,00E+00	2,33E-03	1,31E-04	1,76E-03	1,17E-05	1,04E-06	1,20E-03
Abiotic depletion (fossil fuels)	MJ	3,94E+03	1,01E+02	0,00E+00	7,02E+03	3,16E+03	5,35E+03	2,49E+02	3,13E+01	6,54E+03
Global warming (GWP100a)	kg CO2 eq	2,99E+02	6,94E+00	0,00E+00	4,77E+02	2,36E+02	3,62E+02	1,73E+01	9,56E-01	4,78E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	4,03E-05	1,21E-06	0,00E+00	8,02E-05	3,41E-05	6,03E-05	3,16E-06	3,83E-07	7,00E-05
Human toxicity	kg 1,4-DB eq	1,85E+02	2,10E+00	0,00E+00	1,79E+02	2,09E+01	1,44E+02	2,97E+00	1,98E-01	2,39E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,90E+01	8,43E-01	0,00E+00	6,71E+01	3,91E+01	5,32E+01	5,67E-01	8,95E-02	1,23E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,29E+05	2,39E+03	0,00E+00	1,86E+05	2,75E+04	1,46E+05	1,75E+03	2,56E+02	4,85E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	3,12E-01	1,09E-02	0,00E+00	8,14E-01	1,35E+01	6,35E-01	6,93E-03	9,93E-04	2,47E+00
Photochemical oxidation	kg C2H4 eq	6,23E-02	1,28E-03	0,00E+00	9,98E-02	4,03E-02	7,87E-02	3,24E-03	2,69E-04	9,83E-02
Acidification	kg SO2 eq	1,65E+00	3,29E-02	0,00E+00	2,27E+00	6,84E-01	1,72E+00	8,22E-02	7,10E-03	2,44E+00
Eutrophication	kg PO4--- eq	2,33E-01	8,31E-03	0,00E+00	5,92E-01	9,36E-02	4,55E-01	1,76E-02	1,57E-03	4,23E-01

Table 25 reports the difference of the LCA results for the medium size winery+retail and waste collection case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 25 Difference in the LCA results for a single use and a reusable bottle for medium size winery and retail

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	-4,36E-06	-8,73E-06	-1,31E-05	-1,75E-05	-2,18E-05	-2,62E-05	-3,05E-05	-6,11E-08
Abiotic depletion (fossil fuels)	MJ	0,00E+00	2,10E+03	4,20E+03	6,30E+03	8,40E+03	1,05E+04	1,26E+04	1,47E+04	2,94E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,71E+02	3,42E+02	5,13E+02	6,84E+02	8,55E+02	1,03E+03	1,20E+03	2,39E+00
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	2,01E-05	4,02E-05	6,02E-05	8,03E-05	1,00E-04	1,20E-04	1,41E-04	2,81E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,41E+02	2,82E+02	4,23E+02	5,64E+02	7,05E+02	8,46E+02	9,87E+02	1,97E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	7,77E+01	1,55E+02	2,33E+02	3,11E+02	3,89E+02	4,66E+02	5,44E+02	1,09E+00
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	3,82E+05	7,65E+05	1,15E+06	1,53E+06	1,91E+06	2,29E+06	2,68E+06	5,35E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,81E+00	-3,61E+00	-5,42E+00	-7,23E+00	-9,03E+00	-1,08E+01	-1,26E+01	-2,53E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	3,58E-02	7,17E-02	1,07E-01	1,43E-01	1,79E-01	2,15E-01	2,51E-01	5,02E-04
Acidification	kg SO2 eq	0,00E+00	1,10E+00	2,20E+00	3,30E+00	4,40E+00	5,50E+00	6,60E+00	7,70E+00	1,54E-02
Eutrophication	kg PO4--- eq	0,00E+00	9,71E-02	1,94E-01	2,91E-01	3,88E-01	4,85E-01	5,82E-01	6,79E-01	1,36E-03

Figure 17 GWP savings evolution for medium size winery and retail shows graphically the evolution of the savings in CO2 equivalent emissions at each reuse cycle.

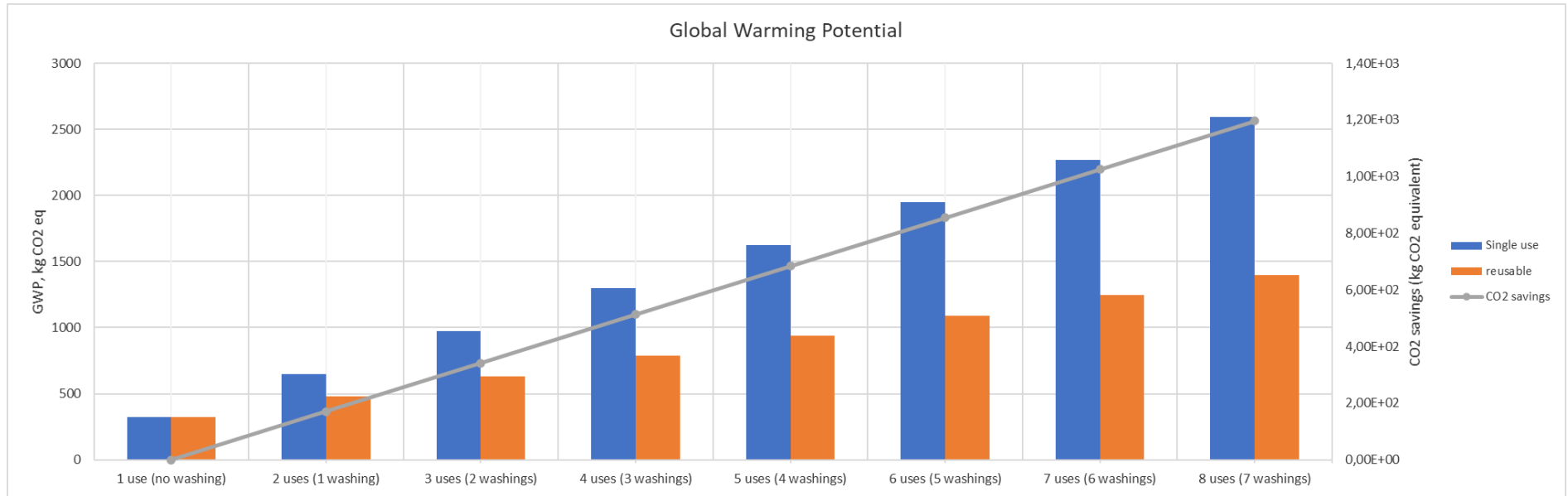


Figure 17 GWP savings evolution for medium size winery and retail

In the case more than one washing per cycle is required, the Table 26 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 26 GWP savings considering distance and number of washings per cycle for medium size winery and retail

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	-6,11E-08	5,77E-06	-1,38E-07	2,36E-06	-8,36E-08	7,50E-07
Abiotic depletion (fossil fuels)	MJ	2,94E+01	4,63E+01	9,89E+00	1,72E+01	2,39E+00	4,82E+00
Global warming (GWP100a)	kg CO2 eq	2,39E+00	3,55E+00	8,23E-01	1,32E+00	2,07E-01	3,73E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	2,81E-07	4,83E-07	9,13E-08	1,78E-07	2,07E-08	4,96E-08
Human toxicity	kg 1,4-DB eq	1,97E+00	2,33E+00	8,28E-01	9,79E-01	2,70E-01	3,20E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	1,09E+00	1,23E+00	4,33E-01	4,93E-01	1,33E-01	1,53E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	5,35E+03	5,75E+03	2,27E+03	2,44E+03	7,49E+02	8,06E+02
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,53E-02	-2,35E-02	-2,24E-02	-2,16E-02	-1,13E-02	-1,11E-02
Photochemical oxidation	kg C2H4 eq	5,02E-04	7,16E-04	1,80E-04	2,72E-04	4,87E-05	7,93E-05
Acidification	kg SO2 eq	1,54E-02	2,09E-02	6,01E-03	8,37E-03	1,81E-03	2,59E-03
Eutrophication	kg PO4--- eq	1,36E-03	0,00E+00	5,02E-04	1,10E-03	1,41E-04	3,40E-04

4.2.9. Evaluation of large size winery scenarios +retail+ waste collection point (E2)

Table 27 reports the LCA results for the large size winery+ retail and waste collection point case study considering 8 reuses (7 washes) for 500 wine bottles.

Table 27 LCA results for 500 wine bottles and 8 reuses for large size winery and retail

		Production	Transport to winery	Distribution	Transport to washing	washing	Transport to winery	Transport end of life	Waste management	Total
Abiotic depletion	kg Sb eq	5,02E-04	3,48E-05	0,00E+00	2,15E-03	1,31E-04	2,15E-03	1,07E-05	9,46E-07	1,18E-03
Abiotic depletion (fossil fuels)	MJ	3,59E+03	1,01E+02	0,00E+00	6,50E+03	3,16E+03	6,50E+03	2,26E+02	2,86E+01	6,25E+03
Global warming (GWP100a)	kg CO2 eq	2,73E+02	6,94E+00	0,00E+00	4,41E+02	2,36E+02	4,41E+02	1,58E+01	8,71E-01	4,56E+02
Ozone layer depletion (ODP)	kg CFC-11 eq	3,67E-05	1,21E-06	0,00E+00	7,40E-05	3,41E-05	7,40E-05	2,88E-06	3,49E-07	6,71E-05
Human toxicity	kg 1,4-DB eq	1,69E+02	2,10E+00	0,00E+00	1,68E+02	2,09E+01	1,68E+02	2,70E+00	1,80E-01	2,24E+02
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,02E+01	8,43E-01	0,00E+00	6,27E+01	3,91E+01	6,27E+01	5,17E-01	8,15E-02	1,15E+02
Marine aquatic ecotoxicity	kg 1,4-DB eq	3,91E+05	2,39E+03	0,00E+00	1,73E+05	2,75E+04	1,73E+05	1,59E+03	2,33E+02	4,49E+05
Terrestrial ecotoxicity	kg 1,4-DB eq	2,84E-01	1,09E-02	0,00E+00	7,57E-01	1,35E+01	7,57E-01	6,32E-03	9,05E-04	2,45E+00
Photochemical oxidation	kg C2H4 eq	5,68E-02	1,28E-03	0,00E+00	9,31E-02	4,03E-02	9,31E-02	2,95E-03	2,45E-04	9,36E-02
Acidification	kg SO2 eq	1,50E+00	3,29E-02	0,00E+00	2,10E+00	6,84E-01	2,10E+00	7,49E-02	6,47E-03	2,31E+00
Eutrophication	kg PO4--- eq	2,12E-01	8,31E-03	0,00E+00	5,49E-01	9,36E-02	5,49E-01	1,60E-02	1,43E-03	4,08E-01

Table 28 reports the difference of the LCA results for the large size winery+retail and waste collection case study considering 8 reuses (7 washes) compared to 8 cycles of use of a single use bottle (500 reusable bottles versus 4000 new bottles). The last column shows the accumulated savings per bottle.

Table 28 Difference in the LCA results for a single use and a reusable bottle for large size winery and retail

	Units	1 use	2 uses	3uses	4 uses	5 uses	6 uses	7 uses	8 uses- 7 washing	savings/bottle @ 8 uses
Abiotic depletion	kg Sb eq	0,00E+00	-8,49E-05	-1,70E-04	-2,55E-04	-3,40E-04	-4,24E-04	-5,09E-04	-5,94E-04	-1,19E-06
Abiotic depletion (fossil fuels)	MJ	0,00E+00	1,64E+03	3,27E+03	4,91E+03	6,54E+03	8,18E+03	9,82E+03	1,15E+04	2,29E+01
Global warming (GWP100a)	kg CO2 eq	0,00E+00	1,37E+02	2,73E+02	4,10E+02	5,47E+02	6,83E+02	8,20E+02	9,57E+02	1,91E+00
Ozone layer depletion (ODP)	kg CFC-11 eq	0,00E+00	1,51E-05	3,03E-05	4,54E-05	6,05E-05	7,57E-05	9,08E-05	1,06E-04	2,12E-07
Human toxicity	kg 1,4-DB eq	0,00E+00	1,23E+02	2,45E+02	3,68E+02	4,90E+02	6,13E+02	7,35E+02	8,58E+02	1,72E+00
Fresh water aquatic ecotox.	kg 1,4-DB eq	0,00E+00	6,81E+01	1,36E+02	2,04E+02	2,73E+02	3,41E+02	4,09E+02	4,77E+02	9,54E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	0,00E+00	3,42E+05	6,84E+05	1,03E+06	1,37E+06	1,71E+06	2,05E+06	2,39E+06	4,79E+03
Terrestrial ecotoxicity	kg 1,4-DB eq	0,00E+00	-1,84E+00	-3,69E+00	-5,53E+00	-7,38E+00	-9,22E+00	-1,11E+01	-1,29E+01	-2,58E-02
Photochemical oxidation	kg C2H4 eq	0,00E+00	2,89E-02	5,77E-02	8,66E-02	1,15E-01	1,44E-01	1,73E-01	2,02E-01	4,04E-04
Acidification	kg SO2 eq	0,00E+00	9,17E-01	1,83E+00	2,75E+00	3,67E+00	4,58E+00	5,50E+00	6,42E+00	1,28E-02
Eutrophication	kg PO4--- eq	0,00E+00	6,74E-02	1,35E-01	2,02E-01	2,70E-01	3,37E-01	4,05E-01	4,72E-01	9,44E-04

Figure 18 shows graphically the evolution of the savings in CO₂ equivalent emissions at each reuse cycle.

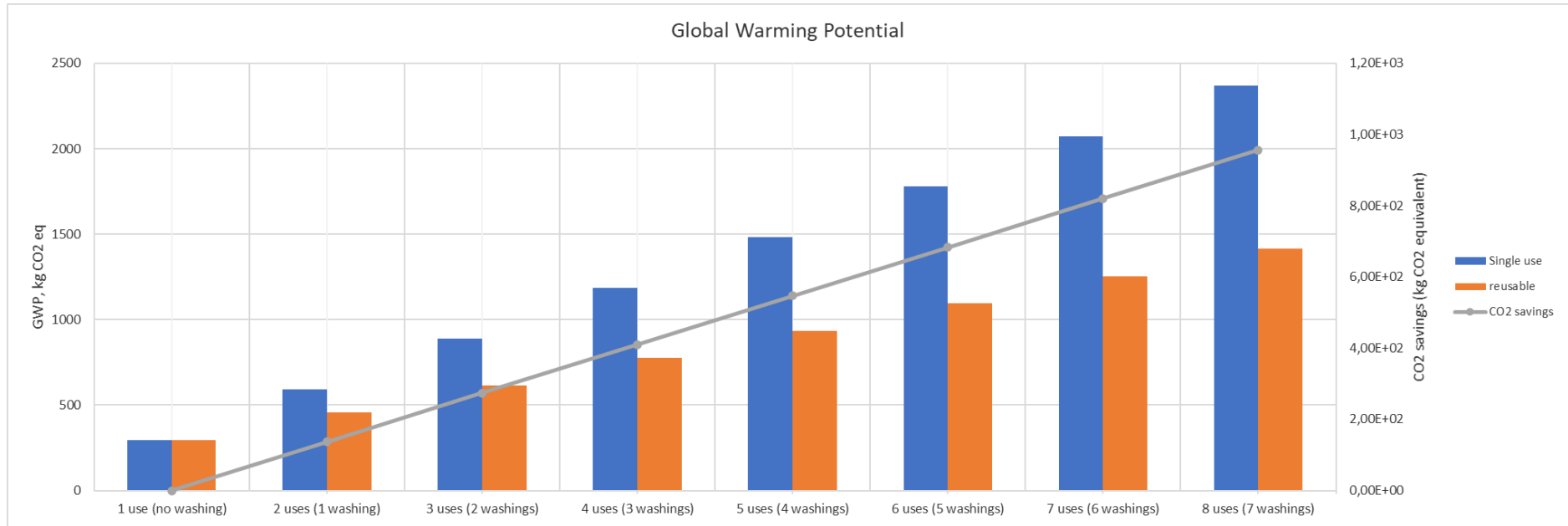


Figure 18 GWP savings evolution for a large size winery and retail

In the case more than one washing per cycle is required, the Table 29 below shows the evolution of the savings per each environmental impact per bottle, considering, for the white columns the current case (REAL) and current distances, and , and for the green columns, an optimal distance of 60 km (OPT.DISTANCE).

Table 29 GWP savings considering distance and number of washings per cycle for the large size winery and retail

IMPACT	UNIT	1 wash per cycle- 8 reuse	1 wash per cycle- 8 reuse (Optimal distance)	2 wash per cycle- 4 reuse	2 wash per cycle- 4 reuse (Optimal distance)	3 wash per cycle- 2 reuse	3 wash per cycle- 2 reuse (Optimal distance)
Abiotic depletion	kg Sb eq	-1,19E-06	5,22E-06	-6,22E-07	2,12E-06	-2,45E-07	6,71E-07
Abiotic depletion (fossil fuels)	MJ	2,29E+01	4,15E+01	7,11E+00	1,51E+01	1,47E+00	4,13E+00
Global warming (GWP100a)	kg CO2 eq	1,91E+00	3,19E+00	6,18E-01	1,16E+00	1,39E-01	3,21E-01
Ozone layer depletion (ODP)	kg CFC-11 eq	2,12E-07	4,34E-07	6,16E-08	1,57E-07	1,08E-08	4,25E-08
Human toxicity	kg 1,4-DB eq	1,72E+00	2,10E+00	7,17E-01	8,82E-01	2,33E-01	2,88E-01
Fresh water aquatic ecotox.	kg 1,4-DB eq	9,54E-01	1,11E+00	3,75E-01	4,42E-01	1,14E-01	1,36E-01
Marine aquatic ecotoxicity	kg 1,4-DB eq	4,79E+03	5,23E+03	2,03E+03	2,22E+03	6,68E+02	7,31E+02
Terrestrial ecotoxicity	kg 1,4-DB eq	-2,58E-02	-2,38E-02	-2,26E-02	-2,18E-02	-1,14E-02	-1,11E-02
Photochemical oxidation	kg C2H4 eq	4,04E-04	6,39E-04	1,39E-04	2,40E-04	3,47E-05	6,83E-05
Acidification	kg SO2 eq	1,28E-02	1,89E-02	4,91E-03	7,51E-03	1,44E-03	2,31E-03
Eutrophication	kg PO4--- eq	9,44E-04	2,47E-03	3,24E-04	9,80E-04	8,14E-05	3,00E-04

4.2.10. Summary of the results by scenarios

This section provides a summary of the results of the LCA analysis for all the case studies and scenarios, focusing on the Global Warming Potential impact category (emissions of CO₂ equivalent). Firstly, Table 30 reports the accumulated savings per bottle after 2 reuses, that correspond to the minimum savings, as this scenario reflects the case where bottles need to be washed 3 times at each reuse cycle, and therefore, only 2 reuses are possible. Results are provided in the case the real distance is applied and, in the case, an optimal distance is applied, between the wineries and the washing facilities.

Table 30 Summary of the GWP savings for 2 reuses

SCENARIOS	CASE STUDIES	Min CO ₂ savings (kg CO ₂ eq/bottle)- real distance	Max CO ₂ savings (kg CO ₂ eq/bottle)- optimal distance	Average CO ₂ savings (kg CO ₂ eq/bottle)
A. HORECA	A1. MEDIUM SIZE WINERY	0,23	0,53	0,38
	A2. LARGE WINERY	0,23	0,47	0,35
B. LARGE RETAIL+ logistics	B1. MEDIUM SIZE WINERY AND RETAIL	0,22	0,34	0,28
	B2. SMAILL SIZE WINERY AND RETAIL	0,31	0,50	0,41
C. Small retail + wine tasting	C1. SMALL WINERY AND TASTE	0,27	0,51	0,39
	C2. SMALL WINERY AND LOCAL STORES	0,238	0,52	0,38
D. Integrated washing	D1. SMALL WINERY AND INTEGRATED WASHING	0,55	0,55	0,55
E. Retail+ waste collection point	E1. MEDIUM SIZE WINERY+RETAIL	0,02	0,51	0,26
	E2. LARGE WINERY+RETAIL	0,206	0,46	0,33

As it can be noticed, savings are approximately 1 order of magnitude larger in the case optimal distances are applied. Figure 19 represents the savings range for the 5 scenarios.

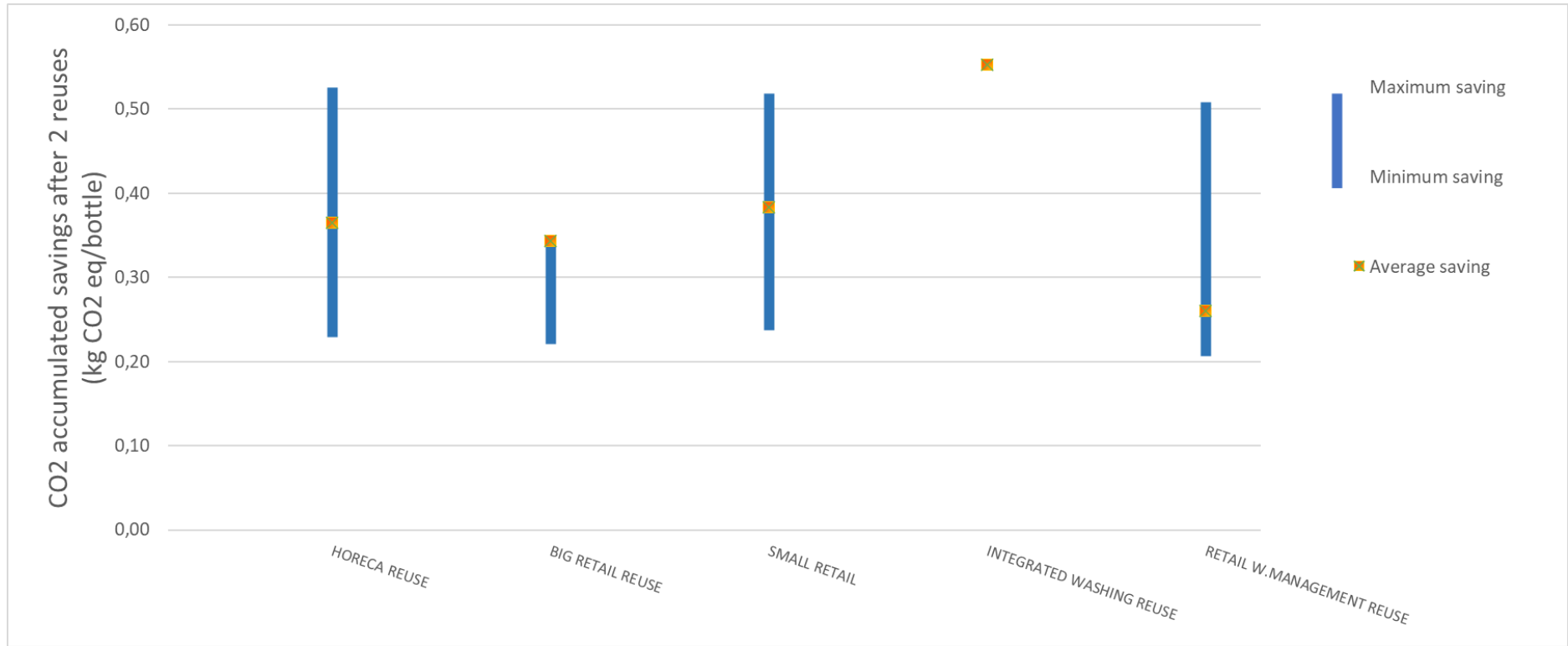


Figure 19 GWP savings range for 2 reuses for each scenario

Table 31 shows a summary of the accumulated savings per bottle after 8 reuses (1 washing per cycle of reuse), considering, both the current distances used in the assessment and a hypothetical case that considers a distance of 60 km.

Table 31 Summary of the GWP savings for 8 reuses

SCENARIOS	CASE STUDIES	Min CO ₂ savings (kg CO ₂ eq/bottle)- real distance	Max CO ₂ savings (kg CO ₂ eq/bottle)- optimal distance	Average CO ₂ savings (kg CO ₂ eq/bottle)
A. HORECA	A1. MEDIUM SIZE WINERY	2,54	3,68	3,11
	A2. LARGE WINERY	2,09	3,31	2,70
B. LARGE RETAIL+ logistics	B1. MEDIUM SIZE WINERY AND RETAIL	2,02	2,37	2,20
	B2. SMALL SIZE WINERY AND RETAIL	2,20	3,50	2,85
C. Small retail + wine tasting	C1. SMALL WINERY AND TASTE	1,90	3,54	2,72
	C2. SMALL WINERY AND LOCAL STORES	1,66	3,63	2,65
D. Integrated washing	D1. SMALL WINERY AND INTEGRATED WASHING	2,32	2,32	2,32
E. Retail+ waste collection point	E1. MEDIUM SIZE WINERY+RETAIL	2,39	3,55	2,97
	E2. LARGE WINERY+RETAIL	1,91	3,19	2,55

As it can be noticed, when lowering the distance up to 60 km, savings are approximately 1,5-2 times larger.

The distance is therefore an aspect to be considered carefully when designing a wine bottle return system, as the benefits could be significantly larger.

For the Catalunya specific case, the distance of 60 km has revealed to be sufficient to cover the zones for each Certification of Origin (D.O) present in the territory. In Catalunya, nowadays there are 11 D.O. spread on all the territory. The area covered by each D.O is variable, but distances are lower than 60-100 km between extreme points in each D.O (see Figure 20).

For this reason, building a washing facility at each D.O will enable that distances to be covered during the bottles transport is around 60 km, maximizing the environmental benefits of the return system.

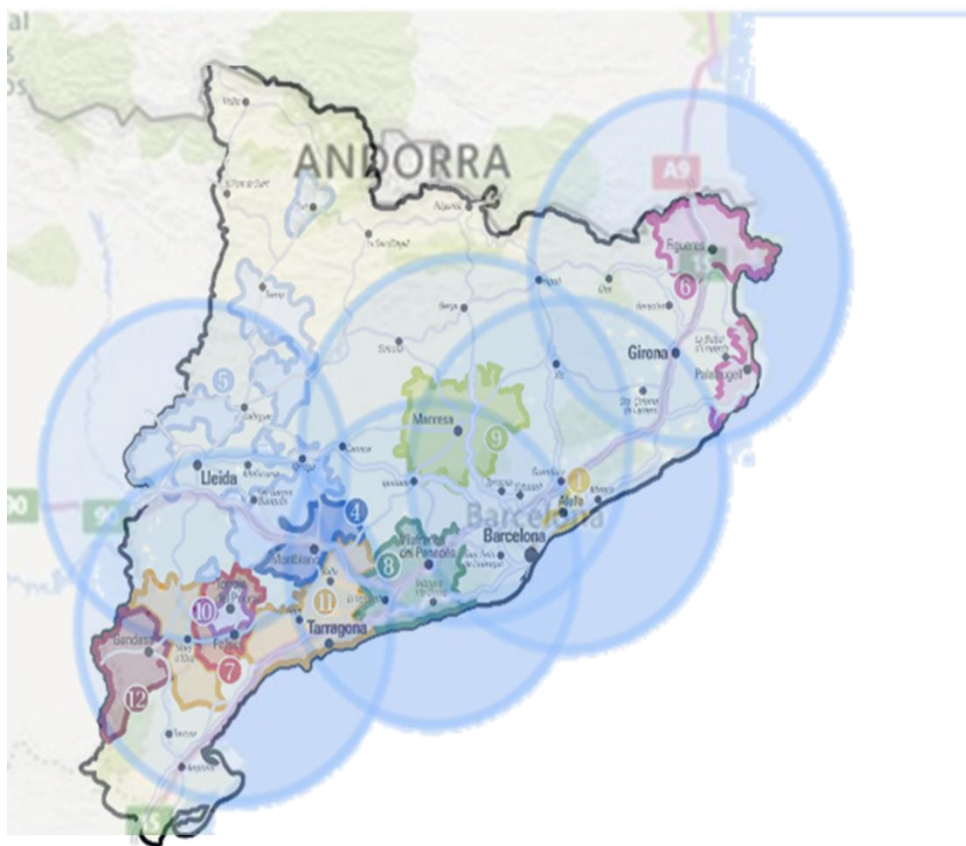


Figure 20 Map of the Catalan Certification of Origin zones for wine and virtual areas of influence of washing facilities

This choice will provide environmental benefits, however the effects of having washing facilities to cover areas of 60 km radius will provide very significant benefits from an economic perspective, as it is explained in the following section.

On the other side, the opposite exercise has been conducted to evaluate which is the maximum distance between the wineries and the washing facility (and in general the distance that need to cover the empty bottles) that allows having CO₂ equivalent emissions savings. Therefore, the maximum distances for each case study have been calculated and reported in Table 32.

Table 32 Maximum distances to obtain CO₂ eq savings

CASE STUDIES	Distances (km)	Comments
A1. MEDIUM SIZE WINERY	1100	Distribution, collection and transport to INFINITY
A2. LARGE WINERY	1050	Distribution, collection and transport to INFINITY
B1. MEDIUM SIZE WINERY AND RETAIL	1150	Distribution to the stores, collection and transport to INFINITY
B2. SMALL SIZE WINERY AND RETAIL	1100	Distribution to the stores, collection and transport to INFINITY
C1. SMALL WINERY AND TASTE	1050	Distribution to the stores, collection and transport to INFINITY
C2. SMALL WINERY AND LOCAL STORES	1100	Distribution to the stores, collection and transport to INFINITY
D1. SMALL WINERY AND INTEGRATED WASHING	1100	Average distance of the distribution and collection of wine bottles
E1. MEDIUM SIZE WINERY+RETAIL	1200	Distribution to the stores, distance to waste collection point and transport to INFINITY
E2. LARGE WINERY+RETAIL	1100	Distribution to the stores, distance to waste collection point and transport to INFINITY

As it can be noticed from the table above, the maximum distances are large enough and they will mean that the location of the washing facilities as it has been during the pilot tests, enables the achievement of CO₂ eq savings.

Therefore, it can be concluded that the distance is not a limiting factor to have CO₂ eq savings, though, as stated previously, reducing the distance would provide larger environmental benefits.

5 Conclusions

This report presents the feasibility analysis carried out in the reWine project to evaluate the return system from an environmental perspective.

From the environmental perspective, it should be remarked that for all case studies included in the reWine pilot tests, the return system provides environmental benefits.

The environmental benefits can be higher or lower, depending on the distance between the wineries and washing facilities and the number of washings required to ensure that the bottle is ready for a new use. For instance, regarding the specific impact concerning carbon footprint (Global Warming Potential, expressed in kg of CO₂ equivalent), accumulated savings after 8 reuses (7 washings) 1,91 to 3,68 kg CO₂ eq /bottle, depending on the winery, the logistics or the distance from/to the washing facilities.

The reduction in the distance between the winery and the washing facility provides additional benefits to the remaining environmental impact categories. For the remaining impact categories, savings are also significant. A special analysis should be done for the Abiotic Depletion Potential (elements) impact category, as this impact depends clearly on the fuel consumption in the transport. For this reason, savings on this impact category are found if distances are reduced.

For this purpose, this study suggests that the creation of new washing facilities, spread along the territory and to have at least one in each Certification of Origin of wine, will enhance the obtaining of comprehensive environmental benefits.

As a general conclusion, reWine project feasibility, considering environmental aspects, is ensured and can be replicated in other regions.

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