Material change for a better environment

Manufacturing / Final Report

The life cycle emissions of wine imported to the UK

This report looks at the impact of transport and packaging on the life cycle emissions of CO_2 of imported wine, and demonstrates the significant carbon benefits from such activities as shipping wine in bulk and the lightweighting of glass wine bottles.

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Front cover photograph: A 24,000 litre flexitank. Source: Trans Ocean Distribution

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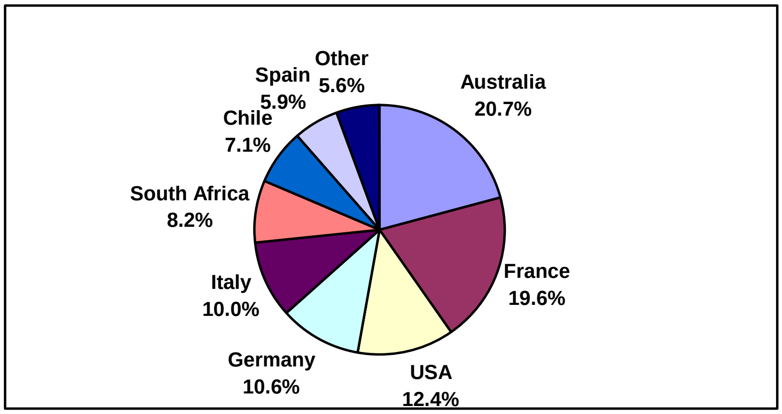
1.0 Introduction

The UK accounts for circa 18% of world wine imports by volume and over 20% by value[1]. Australia and France are the two largest exporters of wine to the UK, accounting for over 40% of the 1.2 billion litres imported into the UK each year, Figure 1.

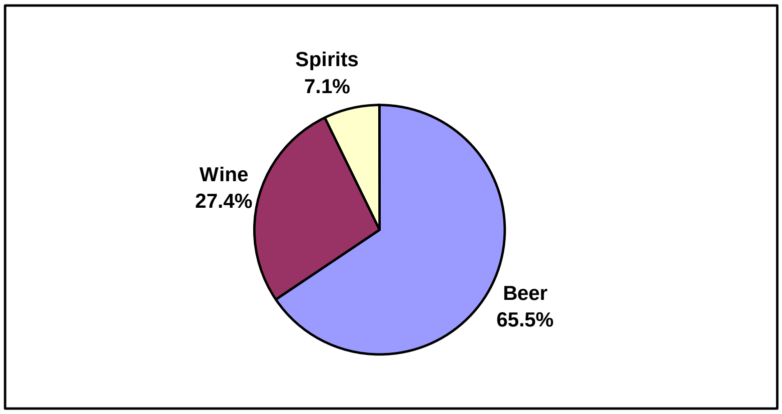
Figure 1 UK wine imports by country of origin (2004)



Source: The Drink Pocket Book 2006. AC Nielsen.

The Food Climate Research Network (FCRN) has estimated that the life cycle emissions from the wine consumed in the UK equates to circa 0.4% of the total UK Greenhouse Gas Emissions[2]. Figure 2 shows how this compares against other types of alcohol with all alcohol consumed in the UK equating to 1.5% of the total UK Greenhouse Gas Emissions.

Figure 2 Breakdown of greenhouse gas emissions from alcohol consumed in the UK, by alcohol type



This case study focuses on the life cycle emissions from wine. The life cycle can be broken down into four key stages (see Figure 3):

- **Total agriculture and alcohol production:** The viticulture stage, i.e. fertiliser application, tending of the vines etc, accounts for nearly three-quarters of the emissions at this stage and viniculture the remaining quarter.
- **Transport:** This includes all the transport stages from the grape grower to the consumer.

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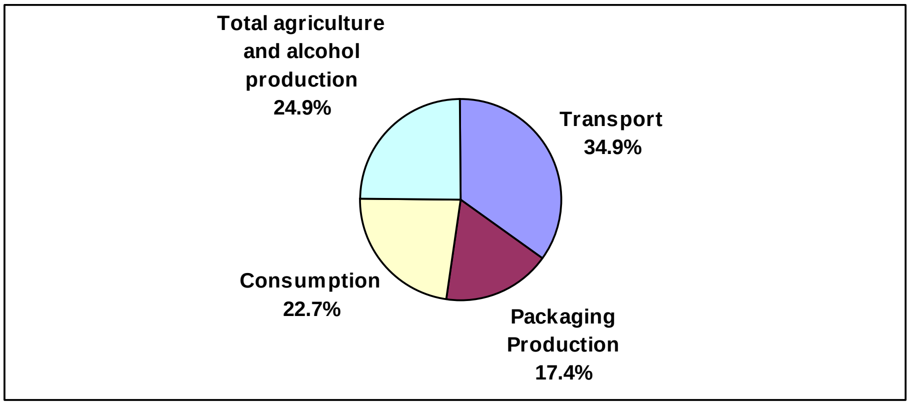
[1] *www.awbc.com.au/winefacts Accessed April 07*

[2] *The alcohol we drink and its contribution to the UK's Greenhouse Gas Emissions: A discussion paper. The Food Climate Research Network Feb 07*

- **Packaging production:** Bottle production accounts for a significant proportion of the emissions at this stage.
- **Consumption**: The refrigeration of white wine accounts for a significant proportion of the emissions at this stage.

Figure 3 Relative contribution of life cycle stages to wine emissions.



Source: The alcohol we drink and its contribution to the UK's Greenhouse Gas Emissions: A discussion paper. The Food Climate Research Network Feb 07

Transport and packaging production are the two stages where significant reductions in life cycle emissions are considered possible and this study focuses on three factors that influence the emissions, namely:

- **mode of long haul transfer:** bulk versus bottled at source[3] and distance
- **mode of transport:** road, rail or sea
- **bottle weight:** lightweighting of bottles.

Two wine growing regions were selected, one in Australia and the other in France, the Berri Estate in Southern Australia and the Bordeaux region of France being the respective locations. Consequently, the Berri Estate was taken as being representative of New World wine and the Bordeaux region representative of Old World wine.

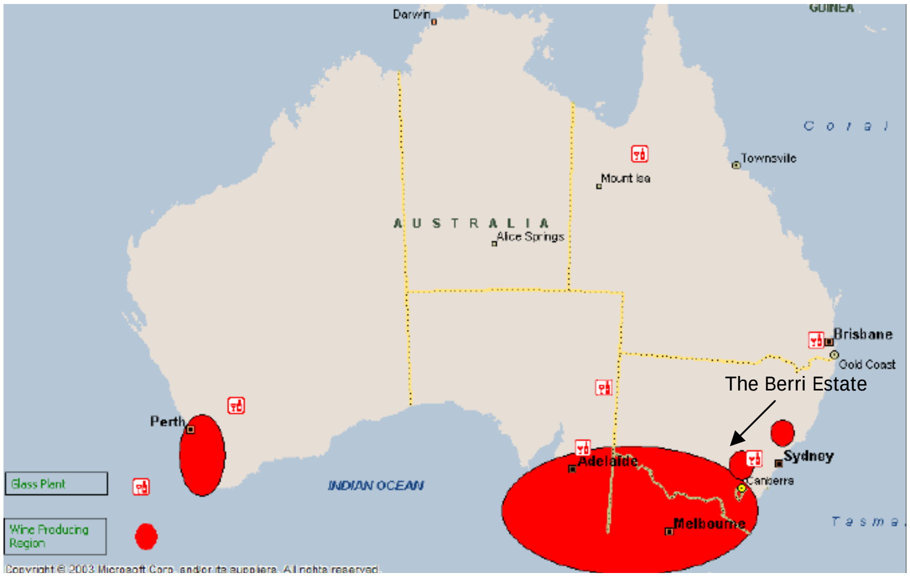
1.1 New World Wine - South Australia

South Australia represents the largest wine making region in Australia and focus within this study is placed on the Berri estate, the largest winery in Australia. The estate is situated 236km north East of the major container port of Adelaide (Figure 4).

[3] *Factors not included within this study include;*

- *Wine bottled at source is frequently stored chilled prior to bottling, whereas wine bulk imported to the UK is stored at ambient temperature in the UK prior to bottling. This could significantly influence the emissions from the storage & filling operations included under "total agriculture and alcohol production" in figure 2.*
- *The bulk importing of blend wines provides an increased level of flexibility in that they can be blended into a number of different wines to meet demand. Pre packaged wine, i.e. wine bottled at source, does not have the same level of flexibility and hence may be stored longer and may have a higher probability of becoming obsolete.*
- *Possible additional pre-bottling filtration of bulk importation post arrival in the UK*

Figure 4 The Australian wine industry.

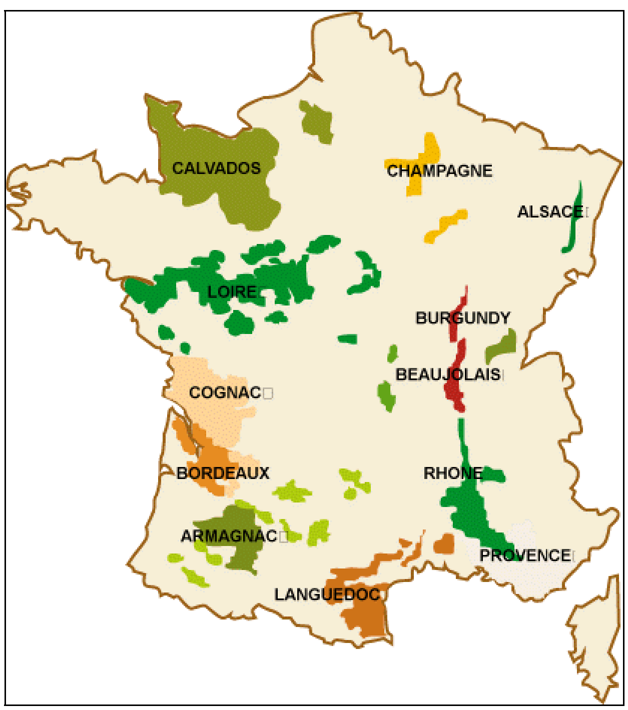


Source: A study of the interaction of imported wine bottles and the UK cullet supply. For WRAP by GTS and Oakdene Hollins January 2006.

1.2 Old World Wine – the Bordeaux Region, France

The Bordeaux region of France is regarded as the heartland of Old World Wine. Situated on the Atlantic coast it is well positioned to export wine to the UK via the container port of Bordeaux, by rail or by road via the northern French ports.

Figure 5 The French wine industry.



Source: www.francetourism.com

2.0 Mode of long haul transfer - bulk versus bottled at source

Traditionally, the wine supply chain was very simple with wine being consumed predominantly in the country of origin. However the globalisation of the wine industry has, as in the case of many other products, extended the supply chain considerably and brought into question the effectiveness of some conventional protocols, such as upstream bottling.

2.1 New World Wine

Figure 6 shows the typical route when importing wine from Southern Australia to Bristol in the UK. Large container vessels are used to transport the containerised wine from Adelaide to Antwerp (Belgium) and then smaller feeder vessels are used for the onward journey to Bristol.

Figure 6 The route map for wine from Adelaide to Bristol.

Source: www.portguide.com

For wine bulk imported from Australia 24,000 litre single trip polyethylene flexitanks or 26,000 litre steel ISO tanks are the two most common types of tanks used. The ISO tank has the advantage of both being reusable and of greater capacity but a significant disadvantage can be the logistical issues surrounding repositioning the tanks for reuse, i.e. returning the empty tanks back to the supplier for refilling. In addition, the ISO tank is more expensive, limiting the number of tanks in circulation and restricting the time the tanks can be retained at the bottling / filling plant. Consequently, the one trip flexitank is becoming more popular.

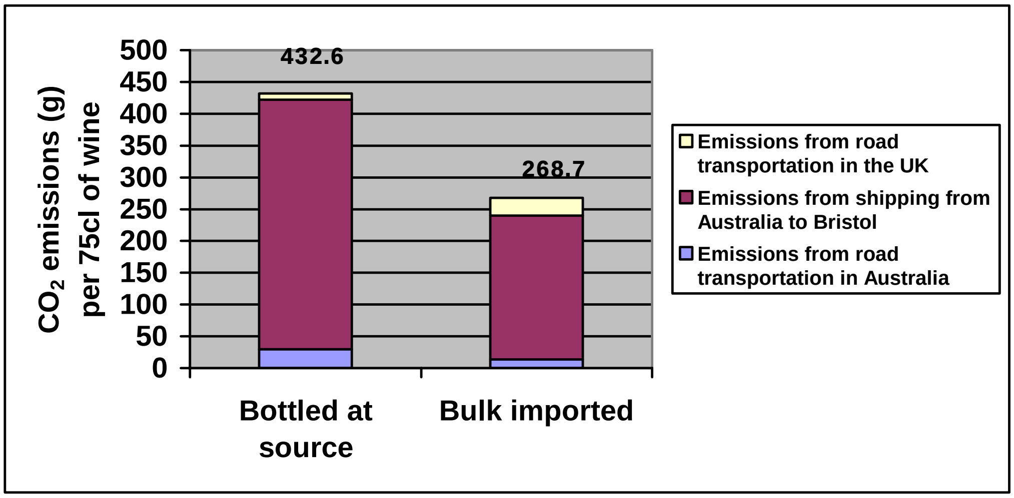
Table 1 shows the comparison of the volume of wine that can be transported in a standard TEU (Twenty-foot Equivalent Unit) when transporting wine bottled at source against bulk transporting wine in ISO tanks and flexitanks. This shows that when bottled at source only 10,584 litres of wine is typically shipped per container equating to 41% of the volume of wine carried per container when shipping the wine in bulk (ISO tanks) or 44% compared with flexitanks.

Table 1 A comparison of packing densities for the three main modes of long haul transfer

Mode of long haul transfer	No. of litres per TEU
Bottled	10,584
ISO Tanks	26,000
Flexitank	24,000

Appendix I, summarised in Figure 7, shows the detailed analysis of the CO_2 emissions associated with the transportation stages when importing wine from Australia. The analysis shows that shipping wine in bulk reduces CO_2 emissions by 164g per 75cl bottle or 38% when compared against bottling at source. In both cases the emissions from long haul shipping dominates, accounting for 91% of the emissions when bottling at source and 84% when shipping in bulk.

Figure 7 CO_2 emissions from the transportation stages when importing wine from Australia.



NB: the emissions from the end consumer are not included in this evaluation due to the number of assumptions required and the lack of robust data.
NB2: the emissions associated with the production and disposal of the flexitank have not been included. However, when dividing the weight of the flexitank (80kg) with the number of bottles (32,000), from a material perspective, only 3.5g of material is used per bottle. Two industry sources report that this material is recycled.

2.2 Old World Wine

Although the port of Bordeaux has the capacity to ship wine to the UK the most common method is by road through the northern ports of Cherbourg and Le Havre (Figure 8).

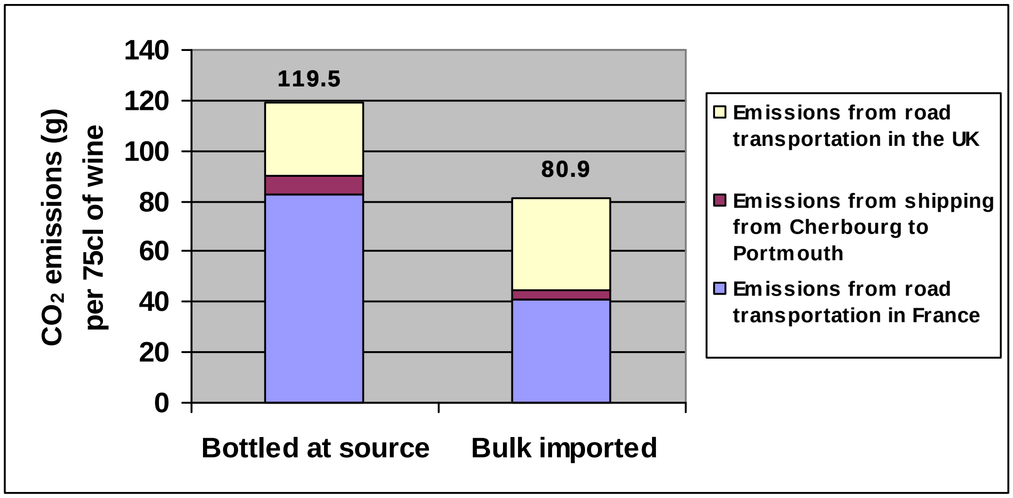
Figure 8 The route map for wine transported from Bordeaux to Bristol.

Source: www.aa.co.uk

Unlike the transportation of bulk wine from Australia the 26,000 litre ISO tank is the preferred method since the logistics of repositioning the tanks for reuse are less complex. In addition, a curtain sided vehicle is the preferred means of transporting bottled wine since it eliminates the need for the containers and hence more bottles can be carried i.e. 17,472 bottles compared with 14,112 bottles.

Appendix II, summarised in Figure 9, shows the detailed analysis of the emissions from transporting wine from Bordeaux to the UK. This, as in the Australian case, shows bulk importing to reduce emissions by over 30% (32%). However, unlike the Australian scenario, the savings arise in the emissions from road transportation in the country of origin (France) rather than the shopping phase. This difference is almost wholly based in the reduced shipping volume due to packing densities, which approximately halves the effective volume per journey.

Figure 9 CO_2 emissions from the transportation stages when importing wine from Bordeaux

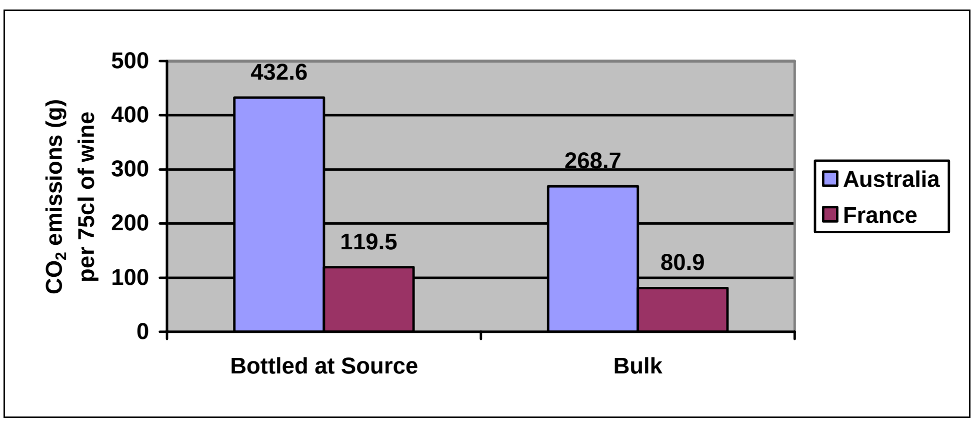


NB: the emissions from the end consumer are not included in this evaluation due to the number of assumptions required and the lack of robust data.

2.3 Geographic proximity - Distance from the UK

Figure 10 shows the comparison of transport emissions for wine bottled at source and bulk imported wine from Australia and France. While the graph shows transport emissions are a function of the distance from the UK, it also shows that significant reductions in transport emissions can be achieved by bulk importing wine over comparatively short distances.

Figure 10 Comparison of transport emissions (From Appendix 1).



2.4 Section Conclusion

The analysis shows that the emissions from the transportation of wine to the UK can be reduced by over 30% by importing in bulk rather than bottling at source, irrespective of whether wine is shipped long distance from the New World or transported the relatively short distance from Old World sources.

3.0 Detailed analysis of Old World Wine Transport - road, rail or sea

Road transportation is the most common method of transporting wine from France. However alternative modes are available especially when importing wine from Old World sources, for example according to FCRN research (2007) three-quarters of the French wine in Marks and Spencer is rail freighted into their distribution centre in Daventry and then road freighted to retail outlets[4]. Alternatively, the port of Bordeaux is able to accommodate feeder ships that can deliver straight to the UK (Bristol). This section therefore considers the CO_2 emissions from alternatives to road transport.

3.1 Analysis

Appendix III shows the detailed analysis of freighting bottled wine by rail from Bordeaux to Daventry and shipping from Bordeaux to Bristol. NB: it is assumed that although different distribution centre locations are used the same retail outlets can be serviced, i.e. retail outlets in the Birmingham area. Figure 11 shows the comparison against road freighting. This shows that the use of rail can reduce transport emissions by about 27% and sea by 17%.

Figure 11 A comparison of transport emissions from road, sea and rail for wine bottled at source in France.

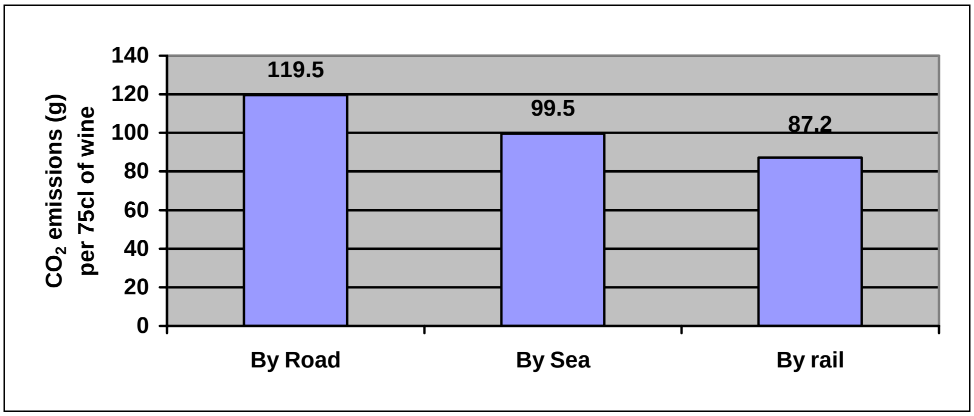
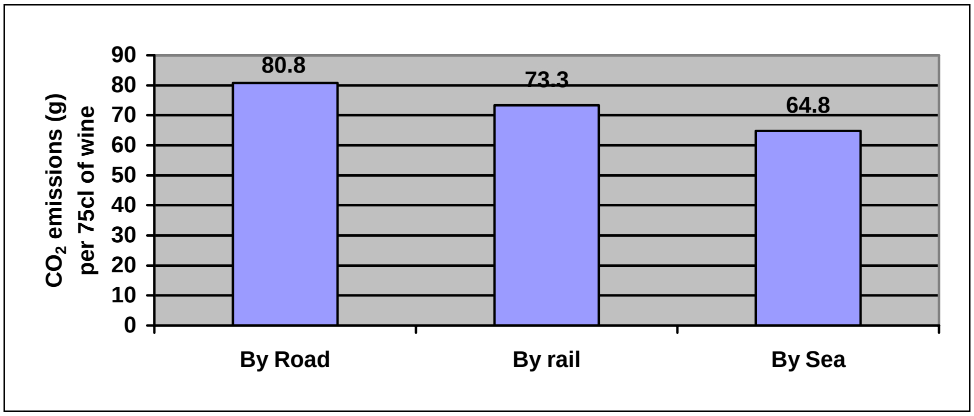


Figure 12 and Appendix III show the comparison in CO_2 emissions when transporting wine in bulk from Bordeaux by road, sea and rail. This shows that a saving of 19.8% could potentially be realised by changing from road to sea and a 9% saving can be achieved converting to rail. The benefit of using rail is hampered by the need to transport the filled tank from the rail terminal at Daventry to the bottling/filling plant and for the filled bottles to make the return journey to the distribution centre. In all cases, bulk importation produces less CO_2 than shipping wine bottled at source, even taking into account the transport to a UK bottling plant.

[4] *The alcohol we drink and its contribution to the UK's Greenhouse Gas Emissions: A discussion paper. The Food Climate Research Network. Feb 07.*

Figure 12 A comparison of transport emissions from road and ship for wine imported in bulk from Bordeaux.



3.2 Section Conclusion

The analysis in this section has shown that the use of alternative modes of transportation, other than road, can have a significant impact on CO_2 transport emissions when transporting wine from Europe. The use of rail can reduce emissions by 27% when importing bottled wine and shipping can save nearly 20% when importing in bulk. Clearly the proximity to a port has a significant bearing on the benefits of shipping and the port at Bordeaux is a major advantage within this region.

4.0 Bottle weight - lightweighting of bottles

Unlike the previous three factors the lightweighting of packaging, and more specifically the wine bottle, impacts on both the emissions from transportation and from packaging production. This investigation looks at the impact lightweighting at source would have on the emissions from wine bottled at source in Australia.

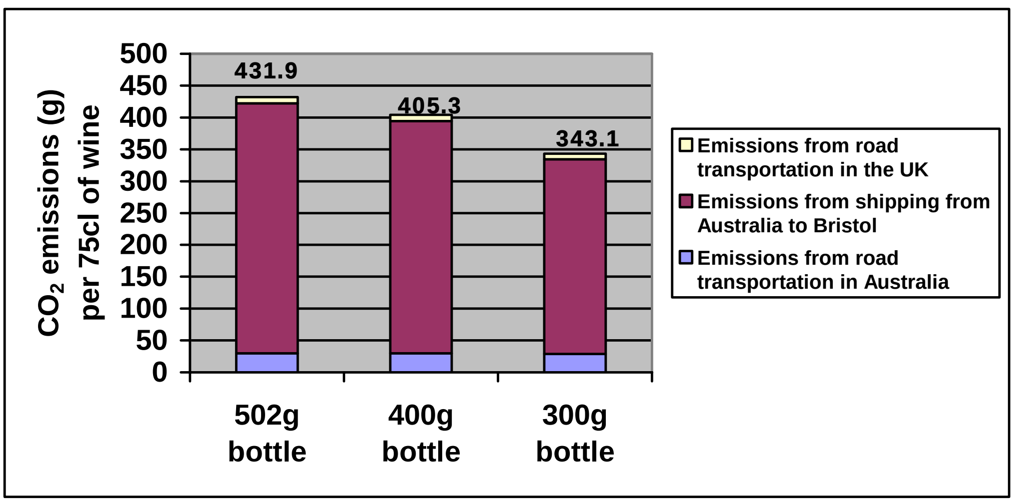
4.1 Impact on emissions from transportation.

A study undertaken by WRAP found that wine bottles in the UK varied in weight from 302g to 893g with the average bottle weighing 502g[5]. This study investigated two light weighting options:

- **A 20% weight reduction** to bring the average weight down to 400g. This represents the half way point between the current average bottles weight (502g) and the current lightest bottle (302g). Experience suggests that this can be achieved with minimum change in bottle design.
- **A 40% weight reduction** to bring the average weight down to the current minimum of 300g. A significant change in bottle design could be needed but this would be counteracted with an increased packing density during shipping, equating to an increase of 2,040 bottles per transport container[5].

Appendix IV shows the detailed analysis, summarised in Figure 13. This shows that the use of minimum weight bottles would result in a 22% reduction in emissions during the shipping stages and an overall reduction of 20%.

Figure 13 The impact of lightweighting on CO_2 emissions from the transportation stages when importing bottled wine from Australia.



4.2 Impact on emissions from packaging production

The impact lightweighting has on emissions during the packaging production stage is dependent on[6]:

- the quantity of recycled material being used in the glass making process. The use of recycled glass (cullet) reduces both the energy requirements to melt the materials, since cullet melts more readily than equivalent batch materials, and the amount of process emissions generated during the glass making process.
- the overall life cycle impacts of the glass making process. Significant factors include the fuel mix used within the glass making process etc.

[5] *Lightweighting 75cl wine bottles, James Ross Consulting for WRAP. Wine Research Presentations, 7th December 2005, WRAP.*

[6] *A study of the balance between furnace operating parameters and recycled glass in glass melting furnaces. Glass Technology Services, September 2004.*

ACI Packaging, a subsidiary of Owens-Illinois Inc report an average recycled content, across all colours, of 40% on all container glass manufactured in their facilities in Australia[7]. Unfortunately very little data is available on the life cycle impacts of glass making in Australia. Therefore it is assumed that the life cycle impacts of glass making in Australia are similar to those of the UK where robust data exists.

Table 2 shows the impact recycled content has on life cycle emissions from the glass making and container production stages. This shows the reported recycled content of 40% would produce life cycle emissions of 719Kg CO_2/t of glass produced.

Table 2 A comparison of recycled content vs life cycle emissions at the glass-making and container production stage.

Recycled Content (%)	Life cycle emissions ($kgCO_2$/t)
0	843
10	812
20	781
30	750
40	719
50	688
60	657
70	626
80	595
90	564
100	533

Table 3 shows the analysis should the weight of wine bottles be reduced by 20% and 40% from the current mean weight of 502g. This shows that a 20% reduction in bottle weight would reduce packaging production emissions by 73gCO_2 per 75cl bottle. A reduction of 40%, to the current minimum weight bottle found on the UK market, would reduce emissions by 145gCO_2 per 75cl bottle.

Table 3 The impact of lightweighting on CO_2 emissions from the packaging production stage.

Bottle weight (kg)	No. of bottles per tonne of glass	Emissions per bottle (gCO_2)	CO_2 savings per bottle (g)
0.502	1,992	719kg/1,992 = 361	
0.4	2,500	719kg/2,500 = 288	73
0.3	3,333	719kg/3,333 = 216	145

4.3 Section Conclusion

This analysis has shown that lightweighting impacts significantly on emissions from both the transportation and packaging production stages in the total life cycle of UK wine imports from Australia, Table 4. A 20% reduction in the average wine bottle weight from the current average of 502g to 400g would reduce emissions by just less than 100g CO_2 per 75cl bottle; representing a 12% reduction in CO_2 from the packaging production and transportation stages in the product life cycle. A 40% reduction from 502g to 300g would save 234g CO_2 per 75cl bottle; representing a 29% reduction in CO_2 emissions from these two stages.

[7] *www.acipackaging.com/aciwww.nsf/frameset?openframeset. Accessed 28th March 2007.*

Table 4 The impact of lightweighting on CO_2 emissions from the packaging production and transportation stage.

Life Cycle Stage	Business as Usual (502g bottle)	Emissions savings using a 400g bottle		Emissions savings using a 300g bottle	
	Emissions per bottle (gCO_2)	Emissions per bottle (gCO_2)	CO_2 savings per bottle (%)	Emissions per bottle (gCO_2)	CO_2 savings per bottle (%)
Transport	432	405	6.2	343	20.6
Packaging	361	288	20.3	216	40.2
Total	793	693	12.6	599	29.5

5.0 Conclusion and Discussion

This report demonstrates the huge potential for reducing CO_2 emissions during the transportation and packaging production stages in the total life cycle for wine imported into the UK. The importing of wine from the New World represents the most significant opportunity for emissions savings based on the fact that the shipping of bottled wine from the New World generates 70% more emissions during the transportation stage than its Old World counterpart.

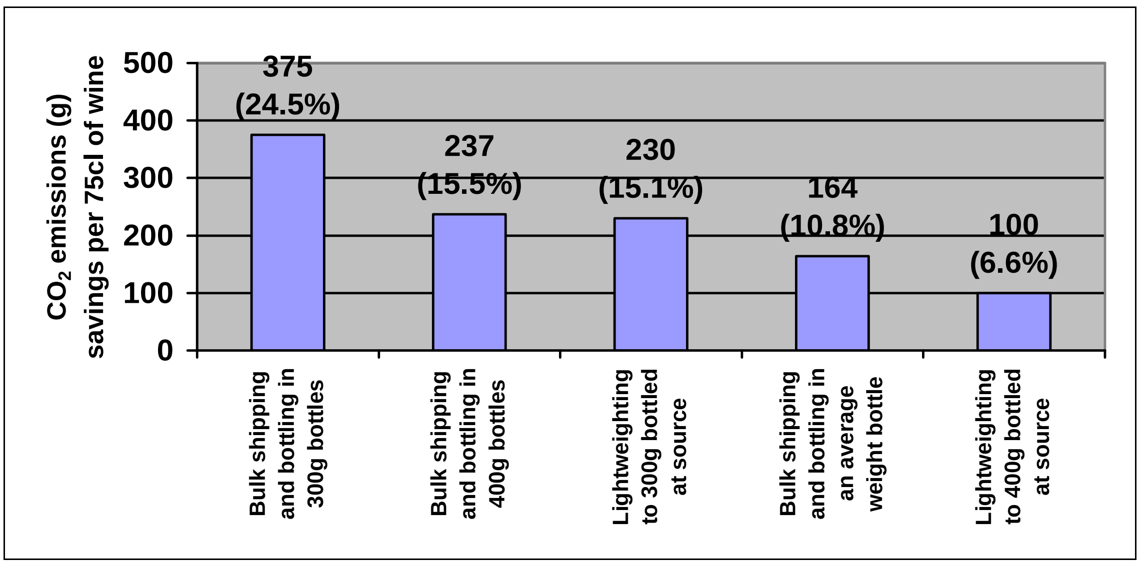
Table 5 shows an estimate of the CO_2 emissions from the production and importation of wine which has been bottled at source in the New World

Table 5 An estimate of CO_2 emissions from the importing of wine from the New World

Life Cycle Stage	Emissions per bottle (gCO_2)	Source
Viticulture	153	The alcohol we drink and its contribution to the UK's Greenhouse Gas emissions: A discussion paper. The Food Climate Research Network Feb 07
Viniculture	178	
Bottling	54	
Packaging Production	361	Table 3 (bottle manufacture only)
Transport	432	Figure 13
Consumption	347	The alcohol we drink and its contribution to the UK's Greenhouse Gas emissions: A discussion paper. The Food Climate Research Network Feb 07
Total	1525	

Figure 14 ranks the different methods of reducing emissions in order of significance and shows that the combination of bulk importing to the UK and lightweighting of bottles to the current minimum weight of 300g would generate a saving of 375gCO_2 per 75cl of wine, representing nearly one quarter of CO_2 emissions.

Figure 14 The ranking of significant factors for reducing emissions from the import of wine from Australia.



The bulk transportation of wine is well proven and it is estimated that 20% of wine is currently bulk imported into the UK from Australia[8]. This equates to emissions savings of 11,000 tonnes[9] of CO_2 per year when compared

[8] *Andy Hartley, Glass Technology Service, Private Correspondence.*

against the traditional "bottled at source". However, the combination of converting the remaining 80% to bulk and the use of 300g lightweight bottles could potentially save a further 122,500 tonnes of CO_2 per year from Australia alone.

The packaging production savings from lightweighting will be similar for New and Old World wines and hence the shift from the current mean weight bottle (502g) to the current lightest weight bottle (300g) would generate an emissions saving of circa 140gCO_2 per 75cl or a total of 44,350 tonnes of CO_2 per year from French wine[10].

In addition, the bulk importing of Old World Wine into the UK and switching from road to rail or ship can have a significant impact on emissions.

To conclude; this study has demonstrated the significant carbon benefits that can be achieved by shipping wine in bulk into the UK and lightweighting of glass wine bottles. To help realise these benefits, in June 2006 WRAP commissioned British Glass to undertake the GlassRite Wine project. The objective of the project is to address the perceived barriers to bulk importation and lightweighting and to improve resource efficiency in the wine supply chain by reducing resource use and encouraging increased use of recycled glass in the UK. British Glass and WRAP are working closely with the wine industry in areas such as the development of lightweight wine bottles that are fit for purpose, allaying fears over customer perception and in terms of bulk importing, providing the necessary reassurance over the quality of the wine.

For more information on the GlassRite projects please contact glassrite@wrap.org.uk

[9] *Based on 251,900,000 litres (335,867,000 bottles) being imported into the UK from Australia (source: The drink pocket book 2006, AC Nielsen)*

[10] *Based on 237,600,000 litres (316,800,000 bottles) being imported into the UK from France (source: The drink pocket book 2006, AC Nielsen)*

Appendices

The data sources for the analysis contained within the appendices were:

5.1 Transport emissions data

5.1.1 Data Sources

The validity of food miles as an indicator of sustainable development. Final report. Annex III: evaluating the impacts of food miles. Defra July 2005. http://statistics.defra.gov.uk/esg/reports/foodmiles/default.asp

5.1.2 Assumptions

All HGV road transport uses highways with an emissions factor of 1438.45g/km
Vehicle emissions are the same for Europe and Australia

5.2 Life cycle stages and distances

5.2.1 Data Sources

WRAP (wine Ready Reckoner base data)
Interviews with industry
Internet route maps including the Fairplay port distance guide.

5.2.2 Assumptions

All bottles are of average weight (502g) unless otherwise stated.
50 litres of wine is left in the bottom of Flexitanks when emptied and 0.3% of wine is lost during the filling stage. Therefore, a 24,000 litre Flexitank generates 31,837 saleable bottles.
10 litres of wine is left in the bottom of ISO tanks and 0.3% of wine is lost during the filling stage. Therefore a 26,000 litre tank generates 34,496 saleable bottles.
Bottle losses during the shipping of cased wine (bottled at source) equates to 0.15%. Therefore 14,090 bottles would be obtained from a container holding 14,112 bottles.
There would be no increases in losses if bottles are designed correctly, i.e. fit for purpose.
It is assumed that the proximity principle will apply within the supply chain, e.g. bottles will be transported from the nearest supplier etc.
All bottles are manufactured in the country in which filling takes place. It is acknowledged that bottles are imported, e.g. the import of bottles from the Far East to Australia and from France to the UK.

5.3 Backhaul data

5.3.1 Data Sources

The validity of food miles as an indicator of sustainable development. Final report. Annex II: Factors driving food miles. Defra July 2005.
Interviews with industry.

5.3.2 Assumptions

A combination of 0%, 77% and 100% backhaul loading has been applied dependent on the type of journey and vehicle type used.

Appendix I

Table A1.1. Australia – bulk hauled

Process	Description	CO_2 emissions / bottle
Transport of empty flexitank from manufacturer to winery in Berri.	Approximately 20 flat packed flexitanks can be transported in a TEU container. Vehicle type standard flatbed artic (emissions in CO_2/Km = 1438.45g). Distance = 269km. Backloading rate = 100%. Equivalent bottle load = 31,837 bottles per flexitank X 20 flexitanks = 636,740 bottles	Total emissions per journey = 269Km X 1438.45g = 386,943g. Emissions per bottle = 386,943g / 636,740 bottles = **0.6g/bottle.**
Transport of filled flexitank from winery to Adelaide docks.	Distance 236 Km. Backloading rate = 77%. Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g). No of bottles per load = 31,837 bottles.	Total emissions per journey = (236km + 54km (empty return)) x 1438.45g = 417,151g. Emissions per bottle = 417,151g/31,837 bottles = **13.0g/bottle.**
Shipping of flexitank from Adelaide to Antwerp via large container vessel	Distance 17,346 Km. Backloading rate = 100%. Ship type = large container vessel (emissions in Kg CO_2/tKm = 0.014). Gross weight of TEU = 2t (empty TEU) + 24t (wine) + 0.08t (Flexitank) = 26.08t	Total emissions per journey = 17,346km X 0.014 Kg CO_2/tkm X 26.08t = 6333.37 Kg CO_2. Emissions per bottle = 6333.37Kg / 31,837 bottles = **198.9g/bottle.**
Shipping of flexitank from Antwerp to Bristol via feeder vessel	Distance = 936km Backloading rate = 100%. Ship type = small container vessel (emissions in Kg CO_2/tKm = 0.037). Gross weight of TEU = 26.08t	Total emissions per journey = 936km X 0.037 Kg CO_2/tkm X 26.08t = 903.2Kg CO_2. Emissions per bottle = 903.2Kg / 31,837 bottles = **28.4g/bottle.**
Transfer of flexitank to bottling facility	Distance = 16 km Backloading rate = 0% Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g).	Total emissions per journey = (16km + 16km (empty return)) x 1438.45g = 46,030g. Emissions per bottle = 46,030g/31,837 bottles = **1.4g/bottle.**
Transport of empty bottles to bottling facility	Distance = 150km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (150km + 34.5km (empty return)) x 1438.45g = 265,394g. Emissions per bottle = 265,394g/17,472 bottles = **15.2g/bottle.**
Transfer of cases from bottling facility to Distribution Centre	Distance = 16km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (16km + 3km (empty return)) x 1438.45g = 28,309g. Emissions per bottle = 28,309g/17,472 bottles = **1.6g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**268.7g/bottle**

Table A1.2. Australia – bottled at source

Process	Description	CO_2 emissions / bottle
Transport of wine to bottling facility via 26,000 litre ISO tank	Distance = 269km Backloading rate = 0% Vehicle type = road tanker (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,667 bottles.	Total emissions per journey = (269km + 269km (empty return)) x 1438.45g = 773,886g. Emissions per bottle = 773,886g/34,667 bottles = **22.3g/bottle.**
Transport of empty bottles to bottling facility	Distance = 50km. Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (50km + 11.5km (empty return)) x 1438.45g = 88,465g. Emissions per bottle = 88,465g/17,472 bottles = **5.1g/bottle.**
Transport of containerised filled cases from filler to Adelaide docks.	Distance 20 Km. Backloading rate = 77%. Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g). No of bottles per load = 14,090 bottles.	Total emissions per journey = (20km + 4.6km (empty return)) x 1438.45g = 35,386g. Emissions per bottle = 35,386g/14,090 bottles = **2.5g/bottle.**
Shipping of container from Adelaide to Antwerp via large container vessel	Distance 17,346 Km. Backloading rate = 100%. Ship type = large container vessel (emissions in Kg CO_2/tKm = 0.014). Gross weight of TEU = 2t (empty TEU) + 10.584t (wine) + 7.056t (glass) + 0.3t (pallets) = 19.94t	Total emissions per journey = 17,346km X 0.014 Kg CO_2/tkm X 19.94t = 4,842 Kg CO_2. Emissions per bottle = 4,842Kg / 14,090 bottles = **343.6g/bottle.**
Shipping of container from Antwerp to Bristol via feeder vessel	Distance = 936km Backloading rate = 100%. Ship type = small container vessel (emissions in Kg CO_2/tkm = 0.037). Gross weight of TEU = 19.94t	Total emissions per journey = 936km X 0.037 Kg CO_2/tkm X 19.94t = 690.6Kg CO_2. Emissions per bottle = 690.6Kg / 14,090 bottles = **49.0g/bottle.**
Transfer of container to distribution centre	Distance = 2 km Backloading rate = 0% Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g).	Total emissions per journey = (2km + 2km (empty return)) x 1438.45g = 5,754g. Emissions per bottle = 5,754g/14,090 bottles = **0.4g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**432.5g/bottle**

Appendix II

Table A2.1. Bordeaux - bulk hauled

Process	Description	CO_2 emissions / bottle
Delivery of 26,000 litre ISO tank to winery for filling	Distance = 100km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = (100km + 100km (empty return)) x 1438.45g = 287,690g. Emissions per bottle = 287,690g/34,496 bottles = **8.3g/bottle.**
Transport of filled tank from winery to Cherbourg docks.	Distance = 634km Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = 634km x 1438.45g = 911,977g. Emissions per bottle = 911,977g/34,496 bottles = **26.4g/bottle.**
Ferry from Cherbourg to Portsmouth	Distance 122 Km. Ship type = large ro-ro vessel (emissions in Kg CO_2/tKm = 0.020). Gross weight of vehicle being transported = 44t	Total emissions per journey = 122km X 0.02 Kg CO_2/tkm X 44t = 107.36 Kg CO_2. Emissions per bottle = 107.36Kg / 34,496 bottles = **3.1g/bottle.**
Transport of filled tanks from Portsmouth to bottle filler (Bristol).	Distance 195 Km. Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = 195km x 1438.45g = 280,498g. Emissions per bottle = 280,498g/34,496 bottles = **8.1g/bottle.**
Return journey from Bristol to Bordeaux	Backloading rate = 77%	(26.3g + 3.1g + 8.1g) * 23% = **8.6 g/bottle.**
Transport of empty bottles to bottling facility	Distance = 150km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (150km + 34.5km (empty return)) x 1438.45g = 265,394g. Emissions per bottle = 265,394g/17,472 bottles = **15.2g/bottle.**
Transfer of cases from bottling facility to Distribution Centre	Distance = 16km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (16km + 3km (empty return)) x 1438.45g = 28,309g. Emissions per bottle = 28,309g/17,472 bottles = **1.6g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**80.9g/bottle**

Table A2.2. Bordeaux - bottled at source

Process	Description	CO_2 emissions / bottle
Transport of wine to bottling facility via 26,000 litre ISO tank	Distance = 100km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,667 bottles.	Total emissions per journey = (100km + 100km (empty return)) x 1438.45g = 287,690g. Emissions per bottle = 287,690g/34,667 bottles = **8.3g/bottle.**
Transport of empty bottles to bottling facility	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 23km (empty return)) x 1438.45g = 176,929g. Emissions per bottle = 176,929g/17,472 bottles = **10.1g/bottle.**
Transport of filled cases from filler to Cherbourg docks.	Distance 634 Km. Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = 634km x 1438.45g = 911,977g. Emissions per bottle = 911,977g/17,472 bottles = **52.2g/bottle.**
Ferry from Cherbourg to Portsmouth	Distance 122 Km. Ship type = large ro-ro vessel (emissions in Kg CO_2/tKm = 0.020). Gross weight of vehicle being transported = 44t	Total emissions per journey = 122km X 0.02 Kg CO_2/tkm X 44t = 107.36 Kg CO_2. Emissions per bottle = 107.36Kg / 17,472 bottles = **6.1g/bottle.**
Transport of filled cases from Portsmouth to distribution centre (Bristol).	Distance 195 Km. Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = 195km x 1438.45g = 280,498g. Emissions per bottle = 280,498g/17,472 bottles = **16.1g/bottle.**
Return journey from Bristol to Bordeaux	Backloading rate = 77%	(52.2g + 6.1g + 16.1g) * 23% = **17.1 g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**119.5g/bottle**

Appendix III

Table A3.1. Bordeaux - bottled at source (transported by rail)

Process	**Description**	**CO_2 emissions / bottle**
Transport of wine to bottling facility via 26,000 litre ISO tank	Distance = 100km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,667 bottles.	Total emissions per journey = (100km + 100km (empty return)) x 1438.45g = 287,690g. Emissions per bottle = 287,690g/34,667 bottles = **8.3g/bottle.**
Transport of empty bottles to bottling facility	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 23km (empty return)) x 1438.45g = 176,929g. Emissions per bottle = 176,929g/17,472 bottles = **10.1g/bottle.**
Transport of filled cases by road to railway station	Distance = 50km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 14,090 bottles.	Total emissions per journey = (50km + 50km (empty return)) x 1438.45g = 143,845g. Emissions per bottle = 143,845g/14,090 bottles = **10.2g/bottle.**
Transport of filled cases by rail to Daventry Distribution Centre.	Distance 1157.1 Km. Vehicle type = train (emissions in g/tkm = 30g). No of bottles per load (TEU) = 14,090 bottles. Gross weight of TEU = 2t (empty TEU) + 10.584t (wine) + 7.056t (glass) + 0.3t (pallets) = 19.94t	Total emissions per journey = 1157.1km x 30g x 19.94 = 692,177g. Emissions per bottle = 692,177g/14,090 bottles = **49g/bottle.**
Transport of cases from distribution centre to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**87.2g/bottle**

Table A3.2. Bordeaux - bottled at source; ship from the port of Bordeaux to Bristol

Process	**Description**	**CO_2 emissions / bottle**
Transport of wine to bottling facility via 26,000 litre ISO tank	Distance = 100km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,667 bottles.	Total emissions per journey = (100km + 100km (empty return)) x 1438.45g = 287,690g. Emissions per bottle = 287,690g/34,667 bottles = **8.3g/bottle.**
Transport of empty bottles to bottling facility	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 23km (empty return)) x 1438.45g = 176,929g. Emissions per bottle = 176,929g/17,472 bottles = **10.1g/bottle.**
Transport of filled container from winery to Bordeaux docks.	Distance = 100km Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles 14,090 per load = 14,090 bottles.	Total emissions per journey = 100km x 1438.45g = 143,845g. Emissions per bottle = 143,845g/14,090 bottles = **10.2g/bottle.**
Ship from Bordeaux to Bristol.	Distance 890 Km. Ship type = small container vessel (emissions in Kg CO_2/tKm = 0.037). Gross weight of TEU = 26.08t	Total emissions per journey = 890km X 0.037 Kg CO_2/tkm X 26.08t = 858.8 Kg CO_2. Emissions per bottle = 858.8Kg / 14,090 bottles = **60.9g/bottle.**
Transfer of container to distribution centre	Distance = 2 km Backloading rate = 0% Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g).	Total emissions per journey = (2km + 2km (empty return)) x 1438.45g = 5,754g. Emissions per bottle = 5,754g/14,090 bottles = **0.4g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**99.5g/bottle**

Table A3.3. Bordeaux - bulk hauled; ship from the port of Bordeaux to Bristol

Process	Description	CO_2 emissions / bottle
Delivery of 26,000 litre ISO tank to winery for filling	Distance = 100km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = (100km + 100km (empty return)) x 1438.45g = 287,690g. Emissions per bottle = 287,690g/34,496 bottles = **8.3g/bottle.**
Transport of filled tank from winery to Bordeaux docks.	Distance = 100km Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = 100km x 1438.45g = 143,845g. Emissions per bottle = 143,845g/34,496 bottles = **4.1g/bottle.**
Ship from Bordeaux to Bristol.	Distance 890 Km. Ship type = small container vessel (emissions in Kg CO_2/tKm = 0.037). Gross weight of ISO tank = 2t (empty tank) + 26t (wine) = 28t	Total emissions per journey = 890km X 0.037 Kg CO_2/tkm X 26t = 856 Kg CO_2. Emissions per bottle = 856Kg / 34,496 bottles = **24.7g/bottle.**
Transfer of ISO tank to bottling facility	Distance = 16 km Backloading rate = 0% Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g).	Total emissions per journey = (16km + 16km (empty return)) x 1438.45g = 46,030g. Emissions per bottle = 46,030g/34,496 bottles = **1.3g/bottle.**
Transport of empty bottles to bottling facility	Distance = 150km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (150km + 34.5km (empty return)) x 1438.45g = 265,394g. Emissions per bottle = 265,394g/17,472 bottles = **15.2g/bottle.**
Transfer of cases from bottling facility to Distribution Centre	Distance = 16km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (16km + 3km (empty return)) x 1438.45g = 28,309g. Emissions per bottle = 28,309g/17,472 bottles = **1.6g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**64.8g/bottle**

Table A3.4. Bordeaux – bulk hauled; transported by rail to Daventry

Process	Description	CO_2 emissions / bottle
Delivery of 26,000 litre ISO tank to winery for filling	Distance = 100km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = (100km + 100km (empty return)) x 1438.45g = 287,690g. Emissions per bottle = 287,690g/34,496 bottles = **8.3g/bottle.**
Transport of filled ISO tank by road to railway station	Distance = 50km Backloading rate = 0% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = (50km + 50km (empty return)) x 1438.45g = 143,845g. Emissions per bottle = 143,845g/34,496 bottles = **4.1g/bottle.**
Transport of filled ISO tank by rail to Daventry Distribution Centre.	Distance 1157.1 Km. Vehicle type = train (emissions in g/tkm = 30g). No of bottles (equivalent) per load (TEU) = 34,496 bottles. Gross weight of TEU = 28t	Total emissions per journey = 1157.1km x 30g x 28t = 971,964g. Emissions per bottle = 971,964g/34,496 bottles = **28g/bottle.**
Transport of filled ISO tank by road to filler	Distance = 62km Backloading rate = 100% Vehicle type = flat bed artic (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = 62km x 1438.45g = 89,184g. Emissions per bottle = 143,845g/34,496 bottles = **4.1g/bottle.**
Transport of empty bottles to bottling facility	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 23km (empty return)) x 1438.45g = 176,929g. Emissions per bottle = 176,929g/17,472 bottles = **10.1g/bottle.**
Transfer of cases from bottling facility to Distribution Centre	Distance = 62km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (62km + 48km (empty return)) x 1438.45g = 158,230g. Emissions per bottle = 158,230g/17,472 bottles = **9.1g/bottle.**
Transport of cases from distribution centre to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**73.3g/bottle**

Appendix IV

Table A4.1. Australia – bottled at source (lightweighting bottles to 400g)

Process	**Description**	**CO_2 emissions / bottle**
Transport of wine to bottling facility	Distance = 269km Backloading rate = 0% Vehicle type = road tanker (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = (269km + 269km (empty return)) x 1438.45g = 773,886g. Emissions per bottle = 773,886g/34,496 bottles = **22.3g/bottle.**
Transport of empty bottles to bottling facility	Distance = 50km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (50km + 11.5km (empty return)) x 1438.45g = 88,465g. Emissions per bottle = 88,465g/17,472 bottles = **5.1g/bottle.**
Transport of containerised filled cases from filler to Adelaide docks.	Distance 20 Km. Backloading rate = 77%. Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g). No of bottles per load = 14,090 bottles.	Total emissions per journey = (20km + 4.6km (empty return)) x 1438.45g = 35,386g. Emissions per bottle = 35,386g/14,090 bottles = **2.5g/bottle.**
Shipping of container from Adelaide to Antwerp via large container vessel	Distance 17,346 Km. Backloading rate = 100%. Ship type = large container vessel (emissions in Kg CO_2/tKm = 0.014). Gross weight of TEU = 2t (empty TEU) + 10.584t (wine) + 5.645t (glass) + 0.3t (pallets) = 18.529t	Total emissions per journey = 17,346km X 0.014 Kg CO_2/tkm X 18.529t = 4,842 Kg CO_2. Emissions per bottle = 4,500Kg / 14,090 bottles = **318.9g/bottle.**
Shipping of container from Antwerp to Bristol via feeder vessel	Distance = 936km Backloading rate = 100%. Ship type = small container vessel (emissions in Kg CO_2/tkm = 0.037). Gross weight of TEU = 18.529t	Total emissions per journey = 936km X 0.037 Kg CO_2/tkm X 18.529t = 641.7Kg CO_2. Emissions per bottle = 641.7Kg / 14,090 bottles = **45.5g/bottle.**
Transfer of container to distribution centre	Distance = 2 km Backloading rate = 0% Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g).	Total emissions per journey = (2km + 2km (empty return)) x 1438.45g = 5,754g. Emissions per bottle = 5,754g/14,090 bottles = **0.4g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 17,472 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/17,472 bottles = **9.6g/bottle.**
Total		**405.3g/bottle**

Table A4.2. Australia – bottled at source (lightweighting bottles to 302g)

Process	Description	CO_2 emissions / bottle
Transport of wine to bottling facility	Distance = 269km Backloading rate = 0% Vehicle type = road tanker (emissions in CO_2/Km = 1438.45g). No of bottles (equivalent) per load = 34,496 bottles.	Total emissions per journey = (269km + 269km (empty return)) x 1438.45g = 773,886g. Emissions per bottle = 773,886g/34,496 bottles = **22.3g/bottle.**
Transport of empty bottles to bottling facility	Distance = 50km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 19,512 bottles.	Total emissions per journey = (50km + 11.5km (empty return)) x 1438.45g = 88,465g. Emissions per bottle = 88,465g/19,512 bottles = **4.5g/bottle.**
Transport of containerised filled cases from filler to Adelaide docks.	Distance 20 Km. Backloading rate = 77%. Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g). No of bottles per load = 16,127bottles.	Total emissions per journey = (20km + 4.6km (empty return)) x 1438.45g = 35,386g. Emissions per bottle = 35,386g/16,127 bottles = **2.2g/bottle.**
Shipping of container from Adelaide to Antwerp via large container vessel	Distance 17,346 Km. Backloading rate = 100%. Ship type = large container vessel (emissions in Kg CO_2/tKm = 0.014). Gross weight of TEU = 2t (empty TEU) + 10.584t (wine) + 4.878t (glass) + 0.3t (pallets) = 17.762t	Total emissions per journey = 17,346km X 0.014 Kg CO_2/tkm X 17.762t = 4,313 Kg CO_2. Emissions per bottle = 4,313Kg / 16,127 bottles = **267g/bottle.**
Shipping of container from Antwerp to Bristol via feeder vessel	Distance = 936km Backloading rate = 100%. Ship type = small container vessel (emissions in Kg CO_2/tkm = 0.037). Gross weight of TEU = 17.762t	Total emissions per journey = 936km X 0.037 Kg CO_2/tkm X 17.762t = 641.7Kg CO_2. Emissions per bottle = 615Kg / 16,127 bottles = **38.1g/bottle.**
Transfer of container to distribution centre	Distance = 2 km Backloading rate = 0% Vehicle type = flatbed artic (emissions in CO_2/Km = 1438.45g).	Total emissions per journey = (2km + 2km (empty return)) x 1438.45g = 5,754g. Emissions per bottle = 5,754g/16,127 bottles = **0.4g/bottle.**
Transport of cases to retail outlet	Distance = 100km Backloading rate = 77% Vehicle type = curtained sider (emissions in CO_2/Km = 1438.45g). No of bottles per load = 19,512 bottles.	Total emissions per journey = (100km + 16km (empty return)) x 1438.45g = 166,860g. Emissions per bottle = 166,860g/19,512 bottles = **8.6g/bottle.**
Total		**343.1g/bottle**

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