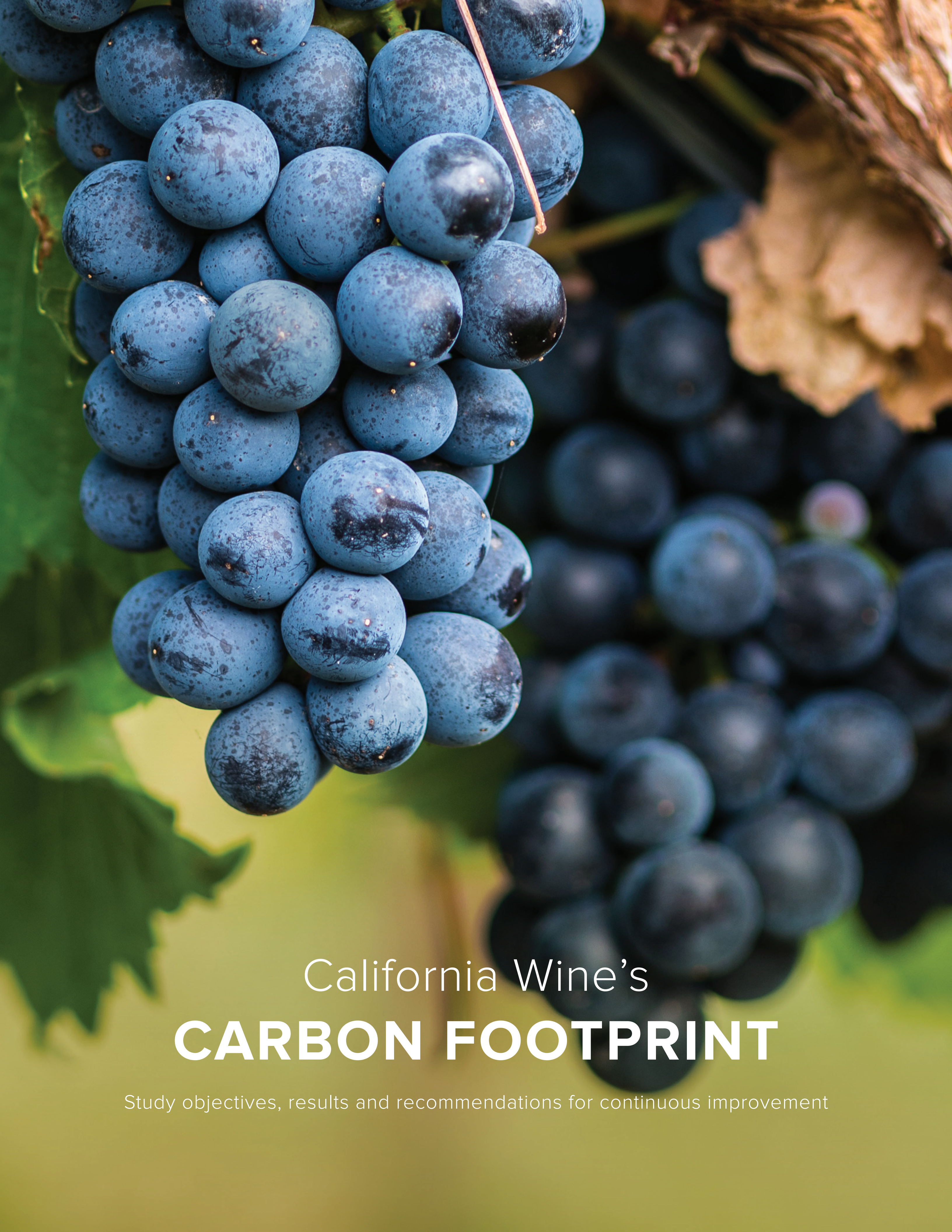


California Wine's CARBON FOOTPRINT

Study objectives, results and recommendations for continuous improvement

The California wine industry has long been committed to sustainable winegrowing and continuous improvement. In 2002, Wine Institute and the California Association of Winegrape Growers published a comprehensive California Code of Sustainable Winegrowing Self-Assessment Workbook, now in its third edition, and in 2003 created the California Sustainable Winegrowing Alliance (CSWA), a nonprofit organization devoted to providing vintners and growers with tools, resources, and workshops to promote the adoption of sustainable vineyard and winery practices[1]. In 2010, CSWA launched a third party certification option, Certified California Sustainable Winegrowing.

While the sustainability efforts of the industry have focused for many years on the areas of energy efficiency, water management, integrated pest management, ecosystem management, etc. the industry began a concerted effort to examine greenhouse gas emissions and climate change mitigation and adaptation in 2007. A literature review and the development of a comprehensive report that consolidates information about greenhouse gas emissions (GHG) and vineyards was undertaken in 2007. Also in 2007, Wine Institute joined together with wine associations from Australia, New Zealand and South Africa to develop the International GHG Protocol and calculator. In 2012, CSWA added Performance Metrics to its online self-assessment and reporting system for energy, water, and nitrogen use, as well as for energy-related GHGs to assist growers and vintners in measuring and tracking their resource use and related emissions. CSWA also worked with scientists to better understand the carbon and nitrogen fluxes occurring in the vineyard soil by calibrating and field testing the internationally used DeNitrification and DeComposition (DNDC) tool, which was then integrated into the Performance Metrics in 2013.[2]

In 2011, Wine Institute commissioned PE INTERNATIONAL to conduct a carbon footprint assessment of the California wine industry to better understand the specific areas within the winegrape growing and winemaking processes that have the greatest impact on GHG emissions. Since a carbon footprint assessment takes into account the life cycle of the product, it is a useful way to identify where opportunities exist to reduce the product's carbon footprint. The results of the carbon footprint assessment, completed for a 9L case of wine, are shown in Figure 1. The areas with the most opportunity for improvement to reduce a vineyard or winery's carbon footprint (also known as "hot spots" using the carbon footprint assessment terminology), are:

- Packaging, particularly the use of glass bottles;
- Vineyard field emissions, particularly nitrous oxide (N_2O) associated with bio-geochemical processes and nitrogen application;
- Vineyard and winery electricity usage for operations; and
- Distribution of packaged wine throughout the U.S. using truck and rail transport.

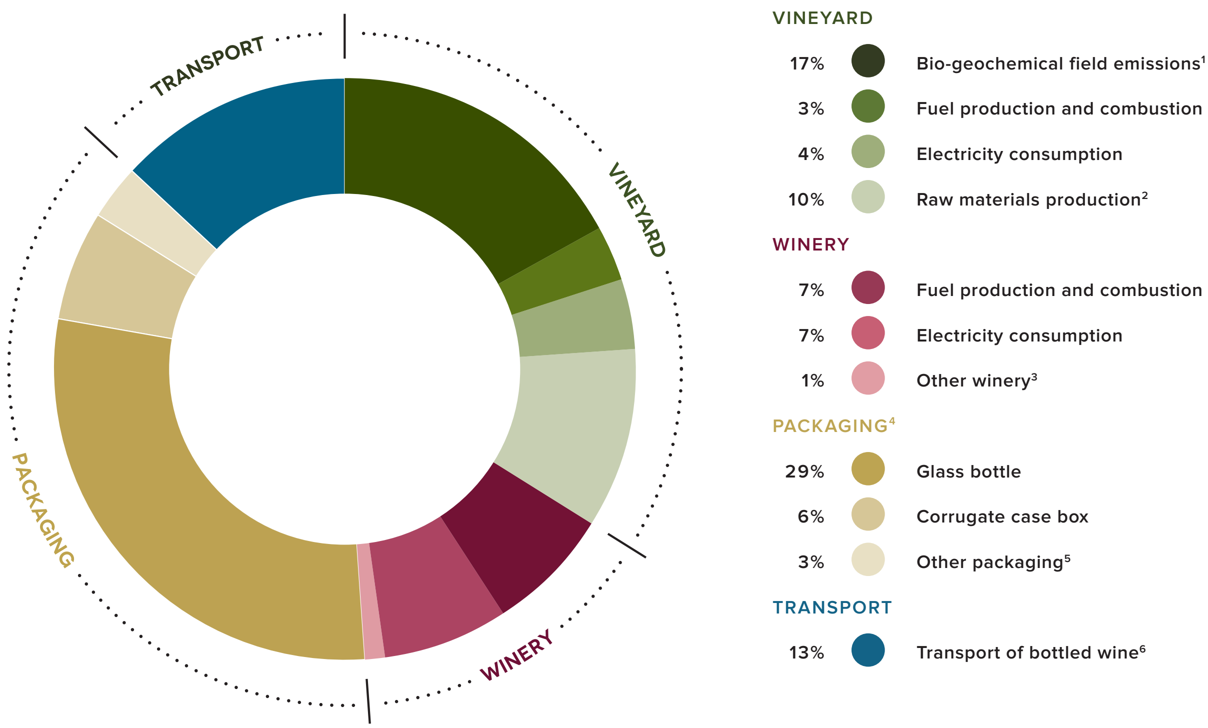
It is important to view these findings with an understanding that the results show an industry wide perspective on GHG emissions, but are expected to be representative of individual vineyards and wineries. Companies that want to understand their specific footprint should use the existing wine industry tools such as the International GHG Protocol and CSWA's Performance Metrics facility carbon footprint calculator. Suggested improvement opportunities for the industry associated with these four areas are provided in Table 1.

Many of the best practices already in use by the industry, and identified in the California Code of Sustainable Winegrowing, can help reduce the carbon footprint of wine. With the goal of continuous improvement, California growers and vintners can use the results of this study as a guide when considering opportunities to reduce their carbon footprint. Many opportunities for carbon footprint reduction will also lead to efficiencies in operations and reduced costs associated with raw material and energy purchases. Further, reduction of GHG emissions can help address regulatory and market pressures and mitigate business risk.

[1] Since 2002, CSWA has promoted continuous improvement in the wine industry through the Sustainable Winegrowing Program (SWP). More than 1,800 vineyards and wineries have participated, and over 10,000 growers and vintners have attended educational workshops. www.sustainablewinegrowing.org

[2] For more information: www.sustainablewinegrowing.org/docs/Vineyards_GHGs_Handout.pdf

FIGURE 1 Relative impacts for the carbon footprint of packaged wine, cradle-to-retail gate



[1] Footprint associated with greenhouse gas emissions that are a result of natural bio-geochemical processes and impacted by local climate, soil conditions, and management practices like the application of nitrogen fertilizers.

[2] Footprint associated with the manufacture and shipment of materials used at a vineyard such as fertilizers and pesticides.

[3] Footprint associated with the transport of grapes from vineyard to winery, raw material production, refrigerant losses, and manufacturing waste treatment.

[4] Footprint associated with the manufacture and shipment of materials used for packaging wine.

[5] Footprint associated with the natural cork closure with aluminum foil and treatment of waste at packaging manufacture.

[6] Footprint associated with fuel production and combustion in trucks and trains based on typical distances for the industry when shipping in the United States to retail facilities.

TABLE 1 Improvement opportunities for the California wine supply chain[3]

Packaging	Lightweight glass bottles Switch to alternative packaging designs (e.g.: bag-in-the box, wine kegs, plastic bottles)
Vineyard Field Emissions	Optimize nitrogen management plan
Vineyard and Winery Energy Use	Conduct an energy audit of the vineyard and/or winery Implement energy efficiency measures Install on-site renewable energy options
Distribution	Optimize distribution network Increase percentage of rail transport Switch to a low-emissions fleet Discuss carbon footprint reduction options with your distribution partner(s)

[3] Examples of best practices can be found in the California Code of Sustainable Winegrowing and on the California Sustainable Winegrowing Alliance website (www.sustainablewinegrowing.org)

A SNAPSHOT OF THE CARBON FOOTPRINT

Objectives

CSWA is increasingly focused on understanding full product impacts and quantitative performance outcomes, and on providing tools and information to help wineries and winegrape growers respond to regulatory and market requests. For instance, the industry invested in the modeling of statewide vineyard emissions using the DeNitrification and DeComposition (DNDC) model, and developed online Performance Metrics, including a facility carbon footprint calculator. These tools are intended to help vineyards and wineries understand their carbon footprint so they can adjust management practices to improve resource conservation, reduce cost, and help mitigate climate change.

In response to industry commitment and stakeholder interest in GHG emissions in media, public policy and market arenas, Wine Institute commissioned an industry carbon footprint to identify hotspots and improvement opportunities, and ultimately provide an important baseline for the industry by which to measure its future success.

Approach

This study summarizes the cradle-to-gate carbon footprint of wine produced in California and shipped within the United States. The study includes the extraction and production of raw materials (e.g.: fertilizer, diesel), grape cultivation, transportation of the grapes to wineries, winery operations, packaging, and, finally, distribution to warehouses and retail stores in the United States (truck and rail transport only).

Terms and Definitions

Life Cycle Assessment

(LCA) is the internationally accepted and standardized methodology that defines a systematic set of procedures for "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle".[4] A *cradle-to-grave system* boundary considers the life cycle stages of a product from raw material extraction through to the disposal at the end of life of the product. A cradle-to-gate system boundary considers the life cycle from raw material extraction through an intermediate life cycle stage (e.g.: product production).

Product Carbon Footprints

are a subset of LCA that focus only on the climate change or the global warming potential impact category. A product carbon footprint, reported in CO_2-equivalents, is a measure of *greenhouse gas (GHG) emissions* (carbon dioxide, methane, nitrous oxide, fluorinated gases) over a product's life cycle. Some GHGs have a stronger warming effect than carbon dioxide such as methane with a Global Warming Potential of 25 kg CO_2-equivalents and nitrous oxide 298 kg CO_2-equivalents.[5]

A **Hot Spot** is an area of the product life cycle that has significant potential impact on a given environmental aspect and is identified and generally agreed upon by experts. The intent of identifying hot spots is to understand where to focus improvement initiatives. It only provides relative context within the product life cycle and does not imply a comparison to other products.

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[4] The International Organization for Standardization (ISO) series of voluntary international LCA standards, ISO 14040, outlines the generally accepted principles and requirements for conducting an LCA. www.iso.org

[5] IPCC. Climate Change 2007: Working Group 1: *The Physical Science Basis*. www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html

The study began with an initial hot spot and gap analysis including a review of existing published LCAs on the cradle-to-gate impacts of packaged wine. The result of the analysis indicated that there is a significant range in the carbon emissions attributed to packaged wine—although energy, packaging and distribution were common hot spots. Additionally, most existing studies were Eurocentric, further necessitating the development of a baseline LCA model specific to the California industry.

In order to determine an industry average baseline for the carbon emissions associated with wine production in California, it was important to get a high level of representativeness. Data was collected through a variety of sources; vineyard and winery electricity, fuel and raw material consumption data (2011) were provided by companies who represent 4–5% of total vineyard acreage in California and 84% of cases produced in California. Additional vineyard information was derived from the DeNitrification and DeComposition (DNDC) tool, which models the carbon and nitrogen bio-geochemistry in a vineyard during the life cycle of a grapevine based on conditions such as weather, soil type, and management practice. The DNDC model was used to simulate field emissions in all of the winegrowing regions throughout California and, through calibration and testing, was shown to be an accurate representation of statewide vineyard field emissions.

Data was collected through the Sustainable Winegrowing Program Performance Metrics Calculator, customized questionnaires, and conversations with California growers and vintners. Additionally, the study drew on published guidance documents, consultation with industry experts, and PE INTERNATIONAL's in-house agricultural expertise to create a comprehensive picture of wine production in California.

Data Analysis

For the inputs and outputs of the wine life cycle, a weighted average was calculated using the known production totals for each vineyard and winery that provided data. Outliers were identified and individually assessed as to their inclusion or exclusion within the study. The work was further vetted through literature and conversations with industry experts. The collected information was then translated into quantitative environmental impacts using the GaBi Software for Product Life Cycle Assessments[6]. The results have been interpreted to highlight hot spots and inform industry recommendations for future carbon footprint reductions.

Results and Recommendations

The relative results of the carbon footprint for the California wine industry are summarized in Figure 1. Based on this analysis and depending on the stakeholder (e.g.: vineyard, winery, packaging or distribution company), different strategies can be implemented towards the goal of improving the overall environmental performance of the California wine industry.

Vineyard

Greenhouse gas emissions at the vineyard come primarily from nitrous oxide (N_2O) emissions released from the soil and related to natural bio-geochemical processes, local climate, soil conditions, and management practices like the application of nitrogen fertilizers. Typical N_2O and other field emissions for California were calculated using the DNDC model; the model simulates the interaction of local climate, soils and on-site management practices to predict crop yield and field emissions. The study considered all of the winegrowing regions of California looking at the field level variations. Production weighted average field emission factors were used and are considered highly representative. Understanding how the natural conditions and management practice affect field emissions may allow growers to further optimize their applied nitrogen use, thereby reducing on-farm N_2O emissions. Additionally, minimizing fossil fuel use for equipment will have positive environmental impacts, while also reducing operating costs.

Winery

Impacts at the winery can be attributed primarily to purchased energy, which includes electricity, diesel, and other fossil fuels. While the study considered the use of solar and other renewable energy sources, the overall percentage of renewable energy used in the California winemaking process remains relatively small. Future improvements may be seen through a concerted effort on first increasing energy efficiency (e.g.: refrigeration, lighting, insulating tanks), which would reduce impacts across all categories, and then considering feasibility of alternative energy sources.

Packaging

Impacts from packaging are due to the energy requirements of producing the requisite materials, such as the glass bottle and corrugated box. However, the closure had a relatively small impact on the overall wine life cycle with impacts ranging from 1–3%. Packaging has a significant contribution to the overall California wine footprint and packaging design decisions have the ability to significantly reduce a winery's footprint (refer to Figure 2). For example, light weighting (also called dematerialization) of glass bottles will lead to significant reductions in environmental burden.

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[6] www.gabi-software.com

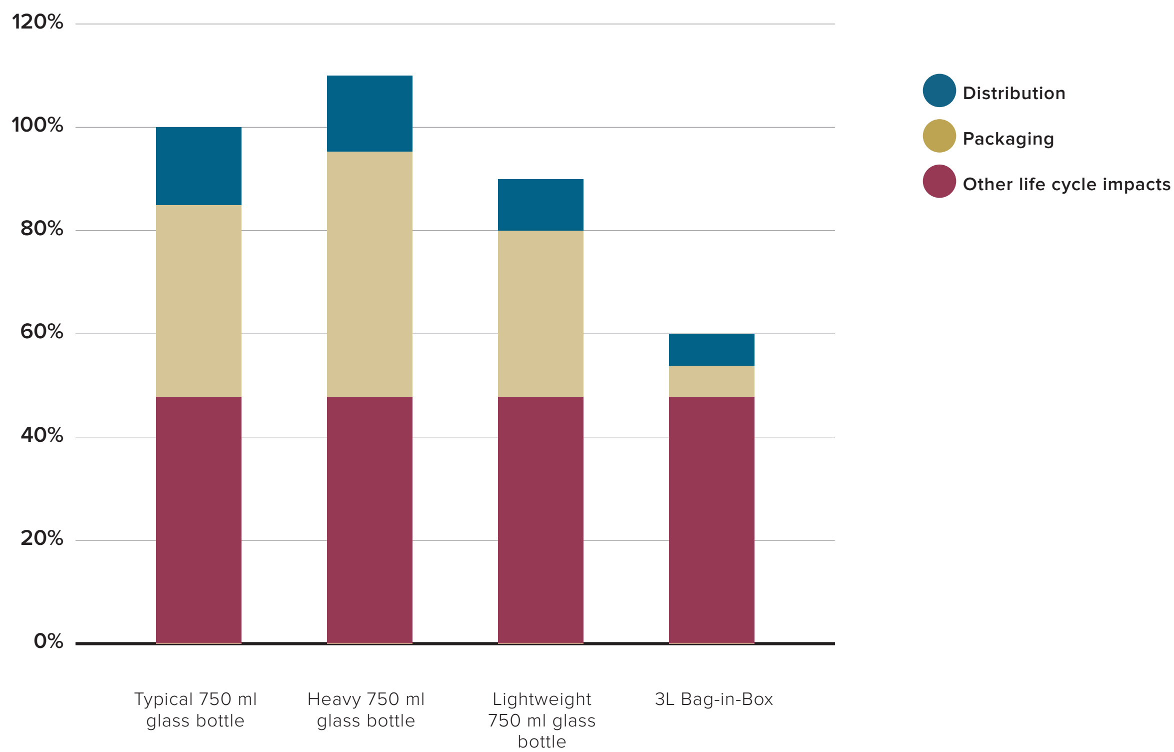
Using less glass also has the benefit of shipping less mass, thereby reducing the burden of distribution. Increasing both the recovery rate as well as the recycled content of new glass bottles can further improve overall packaging impacts.[7] The study showed that bag-in-the-box packaging has the potential to reduce the carbon wine footprint by 40% (Figure 2). While not included in the scope of this study, shipping in bulk reusable stainless steel wine kegs may have environmental benefits by reducing the packaging material and shipping weight burden per case (9L) of wine. Other packaging considerations not included in the scope of this study include quality and consumer preference.

Distribution

While packaging mass and configuration can dictate the distribution burden of California wineries, the mode of transportation (truck vs. rail) can also have a significant impact on the footprint of wine. Within the distribution from the winery to warehouse and retail locations, rail transport was found to be the least carbon-intensive mode of transportation. Therefore, the redesign of distribution networks to incorporate more railways for long haul transport, while still meeting logistic demands, is a key opportunity for improvement, next to optimizing volume utilization, and/or considering low-carbon fuels for distribution vehicles.

FIGURE 2 Packaging alternative assessment for the carbon footprint of packaged wine

Using an average 750 ml bottle as the baseline (100%) and a fixed impact for all upstream life cycle stages (grape and wine production), this graph illustrates packaging impact of various types of glass bottles (traditional, heavy and light weight) and bag-in-box scenarios.



[7] Glass Packaging Institute (GPI). 2010. Environmental Overview. *Complete Life Cycle Assessment of North American Container Glass.* www.gpi.org/sites/default/files/N-American_Glass_Container_LCA.pdf

Conclusions and Potential Next Steps

Based on the outcome of this study, the industry is updating its Performance Metrics to include packaging materials and distribution impacts. This update will enable companies to get a sense of the hot spots in their individual operations. By understanding the carbon footprint of the California wine industry, individual growers, vintners, and distributors can consider how to best use their resources and target specific greenhouse gas reduction activities. Small changes at the facility level can have a large impact on the overall industry footprint if adopted across the industry.

The results of the present study not only help to identify future improvement opportunities for the wine industry, but also point to areas to focus on for future updates of the study. Further refinement of the data collection process will enable a deeper understanding of variation by product, operation, and scale of facilities. Understanding and inclusion of the use phase (e.g.: storage and refrigeration) through a consumer use habit survey will add another level of detail to LCA results. To increase understanding of water consumption within the industry, a water footprint analysis for California vineyards and wineries should also be considered, as this resource is becoming increasingly important, particularly in agriculture supply chains.

Acknowledgements

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Wine Institute

Established in 1934, Wine Institute is the association of 1,000 California wineries and affiliated businesses that initiates and advocates public policy to enhance the ability to responsibly produce, promote, and enjoy wine. Wine Institute works to bolster the economic and environmental health of the state and its communities by encouraging sustainable winegrowing and winemaking practices. The membership represents 85% of U.S. wine production and 90% of U.S. wine exports.

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