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The carbon neutrality principle: A case study in the French spirits sector

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ABSTRACT

According to the 2019 Intergovernmental Panel on Climate Change (IPCC) report, putting in place policies that support sustainable development is imperative. The carbon neutrality concept introduced in 2002 is an efficient way to manage the risks and reduce the vulnerabilities in the land and the food system. Given the pivotal role of sustainability for today's consumers, the low risk and high rewards of carbon neutral production could help businesses transform their entire sector. This article is among the first to show that the carbon neutrality principle offers advantages that far outweigh the costs of maintaining the status quo. The case study of a cognac producer in France suggests that prioritizing sustainable development by reducing emissions could be a beneficial solution, particularly in the high energy spirits industry. Specifically, implementing the three stages (and substages) of the carbon neutral methodology to calculate carbon footprint, this study provides evidence that distilling one hectoliter of pure alcohol produces 0.9 tons of CO₂ emissions. Proposing actions to reduce emissions by 10%, and calculating the offset costs to evaluate the remaining emissions, the study also offers a practical implementation approach and discusses several potential legislative scenarios that might accelerate the transition to carbon neutral production output.

Keywords: Carbon neutral production, Sustainability, Spirits, Carbon footprint, Cognac

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HIGHLIGHTS

- Carbon neutral production can positively transform the high energy spirits sector
- A first empirical examination of a distillery under the CarbonNeutral Protocol
- Reducing emissions is key: 248 tons of CO_{2e} to distil 270 hL of pure alcohol
- Reducing the weight of bottles from 710 to 640 grams cuts emissions by 10%
- Low risk and high reward of Carbon Neutral production far outweigh the costs

1. Introduction

The rapid spread of COVID-19 irrespective of borders has impacted our societies, markets, and industries. Yet, greenhouse gas (GHG) emissions have fallen across the continents as countries imposed lockdowns to halt the proliferation of the coronavirus. The drop in carbon dioxide equivalent (CO_{2e}) emissions is estimated at 5% of the carbon output in 2020¹. Nonetheless, without any structural changes, the decline in emission may be short-lived and thus have a minor impact on the levels of CO_{2e} in the atmosphere. It is therefore urgent “to deploy collective intelligence in the post-pandemic world and envision far-reaching changes to our methods of production and business models” (Bonnafé, 2020). To ensure a sustainable and resilient economic recovery, the carbon neutrality concept introduced in 2002 (Natural Capital Partners, 2020) proposes an efficient way to manage the risks and reduce the vulnerabilities in the land and the food system.

Agricultural production undeniably has a large impact on the environment (Bohlen, 2019; Birkenberg and Birner, 2018; Christ and Burritt, 2013), and the food sector is among those with high carbon emissions (Scholz et al., 2015; Bermeo et al., 2018; Kucukvar et al., 2019). In the wine and spirits sector, sustainability issues have been largely studied in relation to the different managerial aspects of vineyards (e.g. Christ and Burritt, 2013; Marras et al., 2015; Scrucca et al., 2018), consumer perceptions and preferences (Schäufele and Hamm, 2017). Goode and Harrop (2011) cautioned the wine industry that sooner rather than later, wineries will be required to provide information and justification for their practices to address environmentally-concerned consumer demand. Current life cycle assessments in food and agriculture relate to water usage, chemical production scope, and carbon footprint (Litskas et al., 2017; Aguirre-Villegas et al., 2015). In terms of environmental impact of the wine industry, Iannone et al. (2016) examine how the carbon footprint might be improved.

¹ <https://www.power-technology.com/comment/carbon-neutrality-covid-19-impact/>

While many companies have measured their carbon footprint, the means of compensating or reducing it are still limited (Kolk and Pinkse, 2004; Wright and Nyberg, 2017). The growing interest in carbon neutrality for sustainable viticulture (Chiriaco et al., 2019) and other agricultural production (Bohlen, 2019) is an important step in determining potential solutions. Investing in carbon footprint offsets is one of the main impetuses driving industries to seek cost-effective and eco-friendly solutions to become carbon neutral (Choi et al., 2016).

Carbon neutrality defines a means of production where the total output of carbon dioxide during production is neutral, i.e. equal to zero. This does not imply that businesses will have zero carbon emissions, but that these emissions are offset, i.e. counterbalanced. A carbon credit is a tool put in place to provide a free-market solution to carbon offsetting. It is “a transactable, non-tangible instrument representing a unit of carbon dioxide-equivalent (CO_{2e})” (Natural Capital Partners, 2020, p. 6). In simple terms, a carbon credit is a ‘pass’ to emit greenhouse gases (GHG) and still remain carbon neutral, as it proves that the buyer has offset the emissions elsewhere in the world.

Although some companies are ready to commit to carbon neutral strategies and practices, many small and medium enterprises (SMEs) in high energy-consuming sectors hesitate to undertake this shift to mitigate their environmental impact and attain business sustainability. This study therefore aims to help managers understand the advantages of implementing the carbon neutrality principle for energy-intensive industries and SMEs that tend to more reticent to adopt these solutions.

Contrary to the spirits industry, the wine industry, albeit contributing to carbon emissions, does not entail specific energy-intensive processes. Despite this difference, very little research has empirically examined carbon neutrality solutions in the spirits sector. The purpose of this study is an in-depth analysis of the carbon emissions equation in the high energy spirits industry. Overall very little is known about the contribution to the carbon

footprint of different emission factors in the production of spirits. The objective of the study is therefore to examine the carbon neutral methodology and implement the three stages (and substages) to calculate the carbon footprint of a cognac distillery to propose actions to reduce emissions and evaluate the offset costs for the remaining emissions. In particular, two research questions are addressed:

- 1) What are the ultimate advantages of the carbon neutrality principle for specific industries?
- 2) Can applying the CarbonNeutral Protocol framework outweigh the costs of maintaining the status quo in the spirits industry?

To answer these questions, the study investigates in a holistic perspective the emission factors referring to different materials and energy-related inputs, identifying the CarbonNeutral Protocol elements for a path toward enhanced and integrated solutions.

The remainder of the paper is organized as follows. Section 2 provides an overview of the relevant literature. Section 3 explains the methodology based on the CarbonNeutral Protocol that ensures the standardization of results, and when applied to the spirits industry, can lead to substantial advantages. To address the specificities of this industry, the current distillery practices and operational costs are briefly outlined in Section 4 to calculate the cost of carbon neutral production. Real data of a family-owned cognac producer in France are used to analyze the distillery's total emissions according to the CarbonNeutral Protocol framework. Section 5 presents the findings and discusses the results and implications of this work. Finally, Section 6 highlights the contributions, managerial implications, and directions for further research.

2. Related studies: literature review

The abundant literature on sustainability practices in the agriculture, food, and especially the wine sector is somewhat heterogeneous. Thus, the first part of this section focuses on

agricultural sustainability and carbon footprint studies in the wine sector, while the second part recalls the carbon neutrality principle and studies that assess carbon offsets in different sectors.

2.1. Sustainability and carbon studies in the wine sector

Carbon footprint calculations and life cycle assessments (LCA) are at the center of several recent studies in the wine sector to determine the environmental impact. Schäufole and Hamm (2017) present a review of 34 papers examining consumer perceptions, preferences, and willingness-to-pay in relation to wine products with sustainability characteristics. Their results suggest that such wine production and marketing is a profitable strategy in line with consumer attitudes and purchasing motivations.

Over the last decade, an increasing number of academic studies in sustainable practices in the wine and spirits sector have focused on the issues of packaging, organic wine making, and management practices. Bartocci et al. (2017) study the environmental impact of specific wine grape varieties in Italy. Atkin et al. (2012) show significant differences in terms of cost benefits, product differentiation advantages, and performance among wineries that have and have not implemented an environmental management system. Vázquez-Rowe et al. (2013) indicate differences due to wine ageing practices, emphasizing the interest of wineries in sustainability factors. Merli et al. (2018) examine the sustainability programs of the wine sector in the New World, Europe, and Italy, revealing the possibility of merging the best strategies implemented to create an internationally recognized program.

It is generally accepted that carbon emissions are an important environmental indicator in agricultural practices (Vázquez-Rowe et al., 2013; Schäufole and Hamm, 2017; Boccia et al., 2019), and numerous studies on carbon emissions in the wine sector reveal firms' awareness of sustainability practices. Jradi et al.'s (2018) carbon footprint analysis in vineyards shows the possible ways of improving and setting reasonable targets. Rinaldi et al. (2016) perform a

joint assessment of the carbon and water footprint, including all phases of the lifecycle of a wine product. Adopting the LCA method, Vázquez-Rowe et al. (2013) calculate the carbon footprint of nine different types of wine in Italy, Luxembourg, and Spain, exploring the determinants or main factors of diverse carbon footprints. Arzoumanidis et al. (2014) focus on the unresolved issues concerning the exchange of biogenic carbon related to the lifecycle of wine products. Quinteiro et al. (2014) adopt LCA to assess and analyze the impact of quantitative freshwater use on Portuguese wine.

Common conceptions of environmental concerns have emphasized the importance of research (Christ and Burritt, 2013), yet surprisingly there is no consensus on the definition of environmental performance (Jradi et al., 2018). Rugani et al. (2013) highlight the different scopes of carbon footprint calculations. Reich-Weiser et al. (2010) and Scrucca et al. (2018) show that transportation and packaging are the main sources of carbon emissions. Point et al. (2012) analyze the full lifecycle of one 750 ml wine bottle produced and consumed in Canada, showing that not only transportation but also viticulture has a major impact. Depending on the scope, a bottle emits between 0.9 and 2 kg CO_{2e} (Scrucca et al., 2018) or 1.07 +- 0.09 kg CO_{2e} (Bonamente et al., 2016). In reducing the production scope, Litskas et al. (2017) and Marras et al. (2015) highlight fuel consumption and chemical products consumption as the main sources. According to Guo et al. (2017), carbon balance analysis is a new way of understanding a low carbon footprint measure.

2.2. Carbon neutrality studies

The CarbonNeutral Protocol provides a framework to help businesses achieve carbon neutrality (Natural Capital Partners, 2020), outlining the steps for an organization to follow to reach carbon neutrality and obtain carbon neutral certification. Currently, two methodological approaches to the carbon footprint calculation are adopted: one based on the organization, the other on the product.

The CarbonNeutral Protocol can be used to certify a company according to ISO 14067 or ISO 14064. The former focuses on reporting and quantifying the carbon footprint of a product and contributes to number 13 (climate action) of the 17 sustainable development goals (SDGs). The latter goes further and includes number 9 (industry, innovation, and infrastructure) aimed at reporting and quantifying an organization's GHG inventory. Both standards are mainly centered on the environmental pillar and only partly on the carbon criteria. The GHG protocol can be used as a guideline to quantify carbon emissions.

The principal sectors where carbon neutrality has been studied are transportation (and tourism), urban, and energy. The different methods of calculating carbon emissions either implement an energy approach based on the number of liters of fuel used, or a transport approach based on CO₂ tons per km transported. Choi and Ritchie (2014) and Cui et al. (2017) investigate voluntary carbon offsetting and carbon neutrality in air transportation using the energy approach, while Shafiei et al. (2017) undertake a simulation-based comparison between hydrogen and electricity in electric transport. Damsø et al. (2017) analyze the local action plan in the urban sector, and Pechmann et al. (2016) the possibilities for carbon neutral manufacturing using different energies.

In agricultural production, Fantozzi et al. (2015) use ISO 14067 to calculate the carbon footprint of truffle sauce in Central Italy, highlighting the importance of calculating the emission reduction process. Doda et al. (2016) provide evidence that reporting carbon emissions has an impact on their reduction.

Using the CarbonNeutral Protocol allows companies to take a step further and reduce emissions to become carbon neutral. The carbon neutrality methodology is a tool that facilitates sustainable development (Rugani et al., 2013; Vázquez-Rowe et al., 2013). Studying the perceived attitude toward carbon neutral bottles or socially-oriented labels, Pomarici and Vecchio (2014) confirm that some consumers, urban female millennials in

particular, are more likely to buy sustainable wine. According to Chiriaco et al. (2019), sustainable viticulture allows potential carbon neutral production, and the GHG emissions in sustainable vineyards can be totally compensated by the net carbon sink, although wine making processes are not included in their analysis.

All the above studies focus on the wine sector, while the spirits sector has rarely been studied despite the fact that the latter entails specific energy-intensive processes. Even if the principal contributors to GHG emissions in both sectors include transport (and tourism), and high energy use, the spirits sector is known for high energy consumption in the distillation process. In the UK, the alcoholic beverage industry accounts for 1.5% of total GHG emissions, a number that is likely to have been underestimated (Garnett, 2007). The spirits sector has far higher energy consumption, and implementing the carbon neutrality principle could strongly affect firms' cost-efficiency, hence their reluctance.

Although the literature review indicates that the carbon footprint and carbon neutrality concepts have emerged as a political vision around the world in recent years, two broad gaps merit particular attention and hence the questions that this research attempts to address: the practical advantages of the carbon neutrality principle for businesses, and whether adopting the CarbonNeutral Protocol framework outweighs the costs of maintaining the status quo in the spirits industry. The case of a cognac distillery presented below provides an overview of the interplay among the different elements of carbon emission reduction. The main purpose of this study is to propose a complete examination of carbon neutral production with the aim of advancing research in this area and illustrating how the carbon neutral framework might be applied.

3. Methodology based on the CarbonNeutral Protocol framework

As mentioned above, carbon neutrality defines the production outcome where the total carbon output during production is equal to zero. The principal advantage of this

methodology is the framework that ensures the standardization of results. The next section presents the subject and scope definition, the assessment timeframe, and the methodology stages.

3.1. Subject and scope definition

The subject is the entity, product, or activity certified as CarbonNeutral[®]. Due to the intricacies of the business world, the subject has to be clearly defined, and the measuring protocol varies according to its nature. The three scopes of carbon emission measurements are well-explained in the GHG protocol (see Fig. 1): Scope 1 considers emissions from sources that are owned or controlled by the company; Scope 2 considers emissions from electricity consumption (such as purchased electricity, heat, or steam); Scope 3 includes all indirect emissions due to the activities in the upstream or downstream supply chain (raw materials, transportation, etc.).

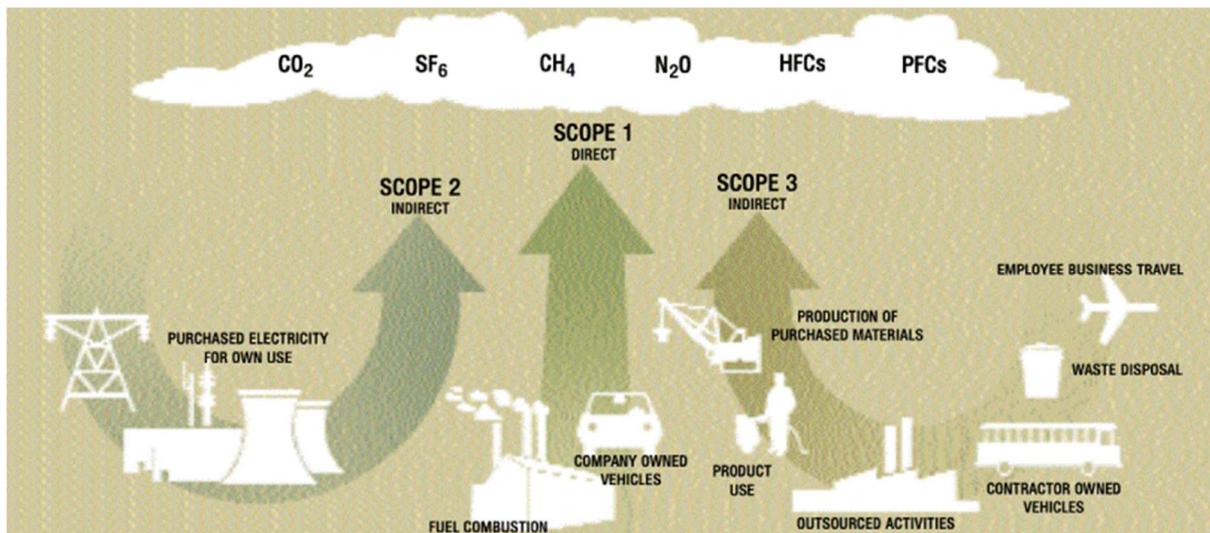


Fig.1. Overview of the scopes and emissions across a value chain (source: Greenhouse Gas Protocol, 2015)

The Kyoto Protocol GHG sources of emissions include: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons, perfluorocarbons, sulphur-hexafluoride (SF₆), and nitrogen trifluoride (NF₃).

For entities, the assessment timeframe is 12 months and should be reassessed each year. Primary data is preferred over secondary data to ensure data quality. When primary data is unavailable, secondary data may be used, including estimations, extrapolations, data from models, industry averages, etc. With regard to data provided by the subject, an uncertainty assessment should be made.

Computing carbon dioxide equivalent (CO₂e) requires two main factors: the emission factor (EF), and the quantity used. Referring to the emission factor as the amount of CO₂e emitted per unit use of product, the amount is computed according to the following simple equation:

$$CO_2e = EF \times quantity\ used \quad (1)$$

The result must be reported in units of CO₂e according to the 100-year potential of each gas.

3.2. Carbon neutral goal

The ultimate goal of the CarbonNeutral Protocol framework is to reach net zero emissions. When the subject (entity, product, or activity) is carbon neutral, it does not imply that it does not emit GHG, it simply indicates that the overall output is equal to zero. However, the next step is to reduce GHG emissions. This can be accomplished in various ways through better management techniques, using efficient equipment, and redesigning operating processes, with carbon neutrality as the prime objective. A carbon reduction action plan “should be reviewed periodically to assess progress against planned actions and to assess the feasibility for further reductions, taking into account the availability of new technologies, enabling policies and incentives provided by government, and the overall business context” (Natural Capital Partners, 2020, p. 37). This action plan can combine reductions in GHG emissions and make use of carbon credits.

3.3. Stages of the methodology

In this study, the CarbonNeutral Protocol framework is adopted according to similar studies developed in other sectors based on the carbon neutral methodology (Damsø et al., 2017; Choi and Ritchie, 2014; Tongdan et al., 2018; Bonamente et al., 2016). The stages and substages of the methodology are summarized in Table 1.

Table 1

<i>STAGE 1: SCOPE DEFINITION OF MEASURING EMISSIONS</i>
<ul style="list-style-type: none">• Define the subject, the scope, and the assessment timeframe• Analyze the production process details in terms of GHG emissions
<i>STAGE 2: IDENTIFICATION OF EMISSION FACTORS AND THEIR MEASUREMENT</i>
<ul style="list-style-type: none">• Identify the emission sources• Break down the different components of the company's costs• Perform an accurate and complete emission analysis
<i>STAGE 3: EVALUATION OF REMAING EMISSIONS</i>
<ul style="list-style-type: none">• Aggregate the measured emissions• Evaluate the remained emissions for an eventual offset• Calculate the offset cost and its impact on the company's costs

4. Results in the spirits industry

In the tradition of studies designed to generate practical insights, a single revelatory case design (Yin, 2013) is used to examine carbon neutrality in the spirits industry. Using real data, the in-depth analysis of the principles and application of the methodology in a family-owned cognac distillery in France allowed determining the distillery's total emissions.

4.1. The spirits sector and distillation process

The spirits industry is known for high energy consumption especially in the distillation process (Garnett, 2007; Jobson, 2014; Roger, 2014). Carefully examining the day-to-day operations in the distillery enabled comprehensively understanding the impact of switching to carbon neutral production.

Although using different distillation processes, the spirit production processes all follow

the same stages of sourcing and fermenting the raw material, i.e. grapes, malt, or agave, distilling the fermented liquid, and optionally aging the distillate. These processes are shown in Fig. 2 and described below to identify the areas that emit the most GHG, those that consume the most energy, and those where the greatest improvements can be made.

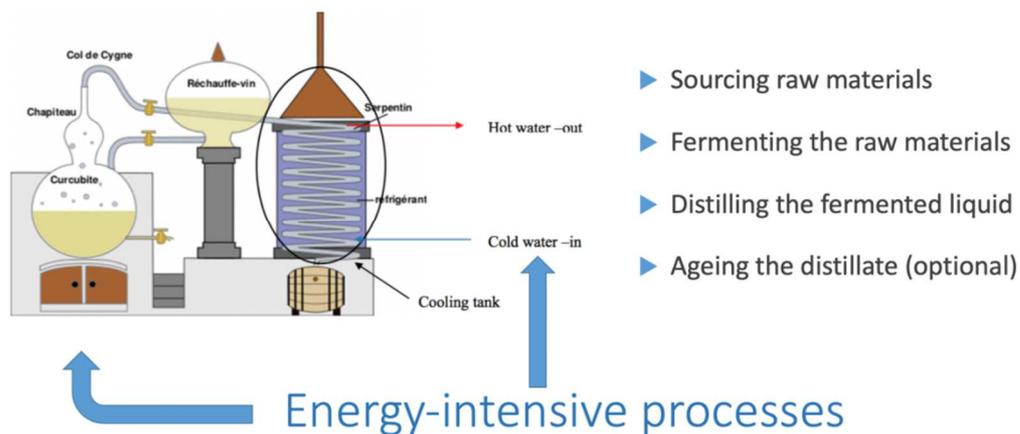


Fig. 2. Current distillery practices

For cognac, the raw material is grapes, and the process starts with mechanical and hand harvesting grapes in vineyards. The harvested grapes are placed in a large trailer pulled by a tractor that takes the trailer full of grapes to the production site (in our case, less than 10 km from the vineyards). Grapes are uploaded into a mechanical press driven by the electricity grid. Once the juice is pressed from the grapes, it is transferred to a tank via an electric pump. The fermentation starts to transform the grape juice into wine. The tanks are monitored and temperature controlled with a cooling/heating system, which is also powered by the electricity grid. When fermentation is complete, the newly made wine reposes for a few months to be distilled afterwards.

At distillation, the first batch of wine is transferred into the crucible, the second batch is stored in the wine heater tank (merely a holding tank, without a heating device). The gas burners under the crucible are fired up and start heating the wine to 86°C. Alcohol has a

lower boiling point (76°C) than water and starts to evaporate first. This evaporation flows through the swan neck through the wine warmer where the next batch is stored. The vapors then pass through a serpentine immersed in cold water inside the cooling tank. This cold water further cools the alcohol vapors back into a liquid. This system is ingenious, first because the vapors passing through the wine warmer lower the temperature of the vapors before reaching the serpentine. Hence, the water contained in the cooling tank does not warm up quickly. Second, it warms up the wine stored in the wine heater and there is no need to burn much gas for boiling. The vapors heat up the wine by caloric exchange. The water contained in the cooling tank is used to cool the alcohol vapors back into a liquid, and must itself be cooled to condense the vapors back into a liquid state. The water is collected at the top of the cooling tank at around 90°C and cooled back down to around $5\text{--}10^{\circ}\text{C}$, then reinjected at the bottom of the tank. Cooling water implies the use of an electrically powered cooling system known as cooling plates. The use of cooling plates is the most common way to bring down the temperature of the cooling water.

Cooling water from 90°C to $5^{\circ}\text{--}10^{\circ}$ through cooling plates requires much energy. However, the distillery under study has devised a resourceful way to cool the water by pumping it onto the side of the distillery's (north facing) wall to let the cool spring air do the majority of the cooling. Once the water reaches the bottom of the wall, the temperature is around 20°C . The cooling plates are used to cool the water further (from 20°C to $5^{\circ}\text{--}10^{\circ}\text{C}$). This system requires less energy than if cooling plates were used to bring the water temperature down from 90° , depending on the season.

The alcohol condensed back into a liquid is then stored in oak barrels, which does not require any energy whatsoever. In some distilleries, the cellars have to be temperature controlled but not in this case, as the temperature is constant at 13°C . Following cognac regulations, after at least one year of aging, the spirit can be called cognac. Once the cellar

master is satisfied with the aging of the spirit, it is bottled in the bottling facility inside a semi-trailer truck and shipped to customers.

At this point, the CarbonNeutral Protocol allows some flexibility with regard to measuring emissions: cradle-to-customer and cradle-to-grave. Cradle-to-customer stops considering emissions once the product has been delivered to the consumer, cradle-to-grave takes everything into account up to the disposal of the product (a bottle of spirit).

The work in the vineyards is relatively low in energy consumption, as it includes mainly hand-pruning and navigating around the vineyards in a tractor. Phytosanitary products (i.e., pesticides) are sometimes used to combat fungi and plant diseases. The manufacturing of pesticides releases a great deal of GHG because these are energy intensive products, and the gases they release during the manufacturing process have a higher CO_{2e} rate (i.e., more harmful than CO₂).

4.2. The distillery's emission analysis

The data requested from the family-owned cognac distillery included all the materials related to labor, energy consumption, products used, and so forth. For confidentiality reasons, the family-owned distillery's name and the precise location in southwestern France are not disclosed. Applying the methodology explained in Section 3, an accurate and complete emission analysis was performed using the CarbonNeutral Protocol framework, as explained next.

4.2.1. Subject definition: the distillery

The distillery under study has an annual output of about eight thousand 700 ml bottles, and sells part of its production as un-bottled to big cognac houses (e.g., Rémy-Martin, Martell, Hennessy, among others). The distillery's vineyards have a total surface area of 24ha. The company controls all the operations, from harvesting to bottling. In recent years,

the distillery has made great strides toward more sustainable vine growing methods and reducing energy consumption. For example, the distillery has installed solar panels on its roof with a designed capacity of 34000 kWh/year, as well as the aforementioned water cooling system using the distillery's north facing wall for maximum natural cooling. The reasons that motivated the company to start and then continue pushing the boundaries of their sustainability are first environmental – they understand the importance of healthcare for their vineyards – and second, economic – as they target financially advantageous solutions for their products.

4.2.2. Scope definition: the five stages of measuring emissions

The data used in the study is from the year 2017, and the scope is detailed in Fig. 3 in line with the three scopes presented in Fig. 1. Any data regarding carbon sequestered by the vineyards are considered. Indeed, carbon sequestration balances grape fermentation (Colman and Pääster, 2007).

In the wine sector, Scope 1 and Scope 2 together account for between 42% and 72% of total emissions (Kerner and Richard, 2007). The wine sector is close to the spirits sector, even if the spirits industry has much higher energy demand (Scope 2) due to distillation. Adding the analysis of Scope 3, a global vision of the carbon emissions of cognac production is obtained.

Breaking down the different components of the distillery's costs, converting these, and summing up the carbon dioxide equivalent (CO_{2e}) enables analyzing how much the distillery would need to offset to become carbon neutral.

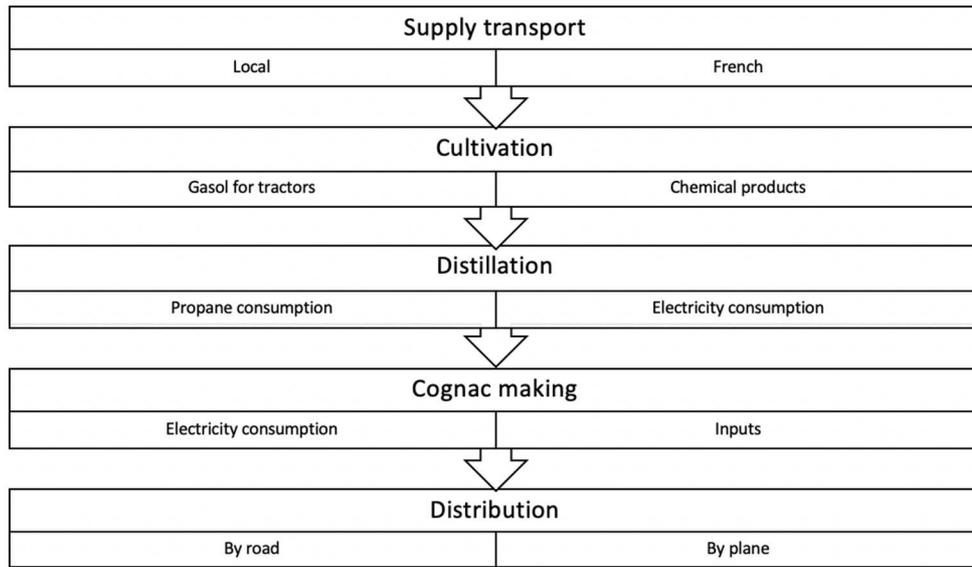


Fig. 3. The study scope

4.2.3. Carbon measurement

The carbon footprint refers to different materials and energy-related inputs: fuel, propane, glass (bottles), electricity, and chemical products. The different emission factors are listed in Table 2. The French Environment and Energy Management Agency (ADEME) calculates the emission factor of fertilizers and herbicides per kg of active elements. The emissions due to the production of these active elements provide the emission factor. For fuel and propane, the scope is the extraction of raw materials and manufacturing of the final product. For freight, the calculation considers fuel combustion. For electricity, each stage of the production process is considered. Important to note is that for the primary energy mix, the electricity emission factor varies greatly from country to country (European Union, 2020). If the same spirit is produced in Great Britain, the emissions due to electricity would be around 10 times higher. Consequently, Scope 2 is country-specific.

Table 2

CO_{2e} emission factors used in the case under study (ADEME).

Source (scope)	Emission factor
Fuel (extraction and combustion)	3.169 kg CO _{2e} /L
Propane (extraction and combustion)	0.26 kg CO _{2e} /kWh

Glass (manufacturing, packaging)	0.81 kg CO _{2e} /kg
Electricity (primary energy mix)	0.082 kgCO _{2e} /kWh
Electricity from solar energy (Chinese manufacturing)	0.06 kgCO _{2e} /kWh
Electricity from solar energy (German manufacturing)	0.032 kgCO _{2e} /kWh
Electricity from wind energy (manufacturing)	0.007 kgCO _{2e} /kWh
Electricity from hydro energy (manufacturing)	0.06 kgCO _{2e} /kWh
Electricity from geothermal energy (manufacturing)	0.045 kgCO _{2e} /kWh
Fertilizers (manufacturing)	5 234 kg CO _{2e} /ton
Herbicides (manufacturing)	9 kg CO _{2e} /kg
Chemical treatment (average - manufacturing)	9 kg CO _{2e} /kg
Freight by road (truck trailer/40tons - fuel combustion)	0.01 kg CO _{2e} /ton.km
Freight by plane (average - fuel combustion)	2.2 kg CO _{2e} /ton.km

Table 3 provides the different consumptions. For example, in the case of electricity, the total consumption of the different buildings in the distillery is considered, to which personal use is added. For the use of chemical products, the real data corresponds to a 24ha vineyard. The principal importers of cognac are the US (40%), Europe (23%), China (14%), and Singapore (13%). Transportation is by plane for the US, China, and Singapore, and by road for Europe.

Table 3

Different consumptions in the case under study.

Source	Consumption for the year 2016
Fuel	7,000 l for their tractors and harvesters
Propane	229,222 kWh for distillation
Glass	5,681 kg for 8 000 bottles
Electricity	8,219 kWh (9,719-1,500)
Fertilizers	11.8 tons
Herbicides	78.9 l
Chemical products	2355 l
Freight by plane	68,020 tons.km
Freight by road	2,600 tons.km

According to the emission factors presented in Table 2 and the consumptions in Table 3, the carbon footprint (CF) is calculated using the following equation (2) elaborated by the

authors:

$$\begin{aligned} CF = & EF_{fuel} \times \text{liters of fuel} + EF_{propane} \times \text{kWh of propane} + EF_{glass} \times \\ & \text{kg of glass} + EF_{electricity} \times \text{kWh of electricity} + EF_{fertilizers} \times \text{tons of fertilizers} + \\ & EF_{herbicides} \times \text{tons of herbicides} + EF_{chemical products} \times \\ & \text{liters of chemical products} + EF_{freight by plane} \times \text{ton.km} + \\ & EF_{freight by road} \times \text{ton.km} \end{aligned} \quad (2)$$

To distil 270hl of pure alcohol in 2016, the calculated carbon footprint of the distillery reached 248 tons of CO_{2e}. The distribution is calculated using the data in Fig. 4. Easy to observe is the small weight of emissions due to electricity. This is a French specificity explained by the high proportion of nuclear energy in the mix. However, the environmental impact of nuclear energy is unquestionable, yet in terms of carbon footprint, the impact is lower than coal. Over the whole fuel cycle, nuclear power emits up to 20 grams of CO₂ per kilowatt-hour of electricity produced, which is two orders of magnitude less than coal². Again, the distribution would significantly differ in another spirit producing country depending on the emission factors of the country's energy production³.

² www.aphref.aph.gov.au_house_committee_isr_uranium_report_chapter4.pdf , p.142.

³ According to Eurostat, for example, the annual amount of CO_{2e} of each French citizen is 5.1 metric tons versus 9.6 metric tons for each German citizen (<https://ec.europa.eu/eurostat>).

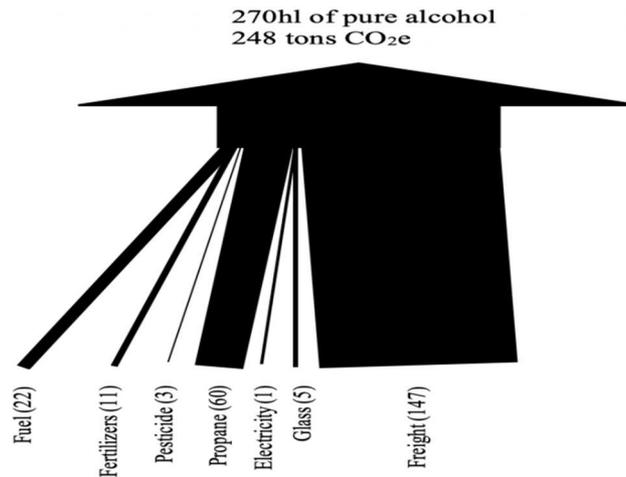


Fig. 4. Carbon footprint of 270hl of pure alcohol (in tons CO₂e).

The main contributor to emissions is freight. This result confirms the findings of previous studies (e.g., Point et al., 2012; Reich-Weiser et al., 2010; Scrucca et al., 2018). The use of other means of transport instead of planes is complex due to the high added value of the product and the required shipping conditions. A surprising result is the second contributor, which is propane consumption. Unlike wine, cognac needs a complementary process, distillation. The induced energy consumption is difficult to improve or reduce.

As mentioned, the distillery has solar panels on its roofs with a designed capacity of 34,000 kWh/year. In 2016 – due to favorable weather conditions – the company produced 36 MWh (35986 kWh) resold to “Electricité de France” (French operator, EDF). Since this is green energy, its production is deductible from their overall carbon emissions. According to French regulations, the distillery cannot directly use the energy from solar panels and must sell it to the supplier (Article 23, Law n°46-628, 8 April 1946)⁴.

As shown in Table 2, the emission factor differs from that of an electricity energy mix. The avoided emissions were calculated and are equal to one ton (Chinese source) or two tons (German source) according to the French Environment and Energy Management Agency (ADEME) data. In 2016, the carbon footprint was 247/246 tons of CO₂e. This decrease is

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https://www.legifrance.gouv.fr/affichTexte.do?jsessionid=377DC58E548462F079F4A72FA1AD26F1.tplgfr29s_1?cidTexte=JORFTEXT000000868448&dateTexte=20040811

negligible compared to the two main sources of emissions, namely propane consumption and freight.

4.2.4. Carbon neutrality goal

To attain the carbon neutrality goal, the company must first reduce its emissions. In accordance with previous studies, transportation is the main source. Applying the best practices from the wine sector, the use of lighter bottles would allow decreasing total emissions. A 10% reduction does not affect the level of quality perceived by customers (Schäufele and Hamm, 2017). Reducing the weight from 710 to 640 grams cuts emissions by 10% due to glass manufacturing (minus 0.5 tons) and transportation (minus 15 tons). The total emissions would be around 231 tons.

Second, to achieve carbon neutrality, the company has to offset the remaining emissions. The distillery's emission analysis revealed that they would need to offset around 231 tons of CO_{2e} to become carbon neutral. According to the CO₂ European Emission Allowances⁵, the average price of one ton of CO_{2e} is 25 € (11/30/19). It would therefore cost the distillery around 5,775 € in carbon credits to offset their entire production. Spread over their 8,000 bottles sold, this equates to 0.72 €. In other words, they would need to increase their prices by a little over 72 cents, which means an increase of less than 2% on the minimum price of a bottle.

If the distillery offsets its entire production, it would not only reach net zero emissions for the bottles it sells but also for the cognac it stores for aging. As mentioned, the company does not sell its entire production. Offsetting total production including future bottles that will be sold after aging – the contents of which are still maturing in barrels – become carbon neutral immediately at the end of the production cycle due to implementing this offsetting strategy.

⁵ <https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances>

5. Findings and Discussion

Our findings provide new insights to current knowledge on the carbon neutrality principle. Previous studies in the wine sector acknowledge and stress the importance of environmentally-friendly practices to reduce emissions and improve carbon footprint (Bonamente et al., 2016; Jradi et al., 2018; Vázquez-Rowe et al., 2013). The emissions in the wine sector have been well researched. Yet, the means of compensating or reducing emissions remain limited, and seeking cost-effective and eco-friendly solutions such as carbon neutrality is urgently required (Chiriaco et al., 2019). This is particular true with regard to the spirits industry, where the distilling processes are high in energy consumption and no carbon free technologies exist (Jobson, 2014). Thus, this study therefore contributes to the literature on carbon neutrality in energy-intensive industries.

5.1. Theoretical and practical findings

Our research confirms the ultimate advantages of the carbon neutrality principle for a specific industry by integrating the CarbonNeutral Protocol elements into a framework and providing a path to enhance integrated solutions that the sector might develop (Doda et al., 2016; Boccia et al., 2019). Managers need to know whether the CarbonNeutral Protocol implies a heavy burden. Demonstrating that the benefits outweigh the costs is an important contribution and should aid managers in adapting their strategies to meet consumer expectations.

By examining how the carbon neutrality principle affects costs, this study adopts a holistic approach rather than investigating specific elements, such as energy intensity (Aguirre-Villegas et al., 2015; Fantozzi et al., 2015), innovation (Birkenberg and Birner, 2018), and transportation issues (Reich-Weiser et al., 2010). The findings are in line with recent studies on the managerial aspects of the environmental impact of the food and agriculture sectors

(Atkin et al., 2012; Arzoumanidis et al., 2014; Bermeo et al., 2017), suggesting that focusing on the global implementation of the CarbonNeutral Protocol framework may be more successful with respect to the component approach in Chiriaco et al. (2019). Our case study confirms that the CarbonNeutral Protocol framework outweighs the cost of maintaining the status quo in the spirits industry. The implementation of this approach to neutralize emissions and incorporate carbon offsetting in the company's sustainability policy and strategy enables clearly communicating the company values and has great potential to respond to the growing expectations of new generations of consumers pursuing environmental and sustainability goals. The low risks and high rewards of carbon neutral production prevail over remaining at a standstill, and instead lead to progress.

Furthermore, by clarifying how the CarbonNeutral Protocol framework affects the different components of the distillery's costs, this study views the transition toward carbon neutrality through a new practical lens. Clearly communicating the values is vital for the new generation of consumers willing to pay a price premium for brands with an environmental purpose (Steenis et al., 2018; Schäufole and Hamm, 2017). Linking our findings on the cost implications and the positive responses of consumers to sustainable wine that Schäufole and Hamm (2017) observe adds a novel perspective to studies in the spirits sector and research on sustainability and carbon neutrality. Our findings support sustainability decision-making by clarifying when adaptation is necessary and how a better strategy – a green strategy – can be adopted (Boccia et al., 2019).

Our analysis suggests that prioritizing sustainable development by reducing emissions is a winning situation for the entire industry. Given the pivotal role of sustainability in the mindset of consumers, carbon neutral production could help businesses transform their entire sector. By moving toward carbon neutrality, small distilleries and large spirit conglomerates could lower costs without compromising their financial situation, strengthen their reputation,

attain positive consumer perceptions and goodwill, attract new customers, and foster loyalty.

Furthermore, businesses need to know if consumers are willing to pay a price premium to buy similar or even the same product manufactured differently. In the case of the spirits industry, the product is still a bottle of spirit, but a carbon neutral one. If by selling these products companies can maintain – or potentially increase – their profits, they will satisfy their fiduciary duty to investors (King and Lenox, 2001) and increase their customers' goodwill.

Future legislation might reinforce the need for distilleries to become earlier adopters of the CarbonNeutral Protocol.

5.2. Legislative changes

According to the recent IPCC report (August 2019), better land management can contribute to tackling climate change. Putting in place policies that support sustainable land management and keeping carbon in the ground while reducing GHG emissions is imperative. It has been proven that changes in legislation that promote agroforestry, better soil management, and reduce food waste are “win-win solutions which can boost land productivity and reduce emissions” (IPCC, 2019). The carbon-neutrality approach is considered the most efficient way to manage the risks and reduce the vulnerabilities in the land and food system.

Future legislative changes might accelerate the transition of distilleries to carbon neutral production output (Bocken and Allwood, 2012; Imasiku et al., 2019). This can be achieved either by incentivizing them through tax-cuts and subsidies, or dissuading them by imposing a carbon tax. Governments might conceivably be willing to accelerate this transition to change production (i.e., to carbon neutral) and impose sanctions on those who do not comply.

The market place would develop differently under the assumption that becoming carbon-neutral is profitable, encouraging companies to start the process toward carbon neutrality,

especially considering that by 2050, the EU should cut greenhouse gas emissions to 80% below the 1990 levels. The milestones to achieve this are a 40% emissions reduction by 2030 and 60% by 2040. All sectors need to contribute. Low-carbon transition is feasible and affordable (European Commission, 2018), and a cohesive set of regulations need to be put in place for a stable carbon neutral market to emerge.

5.3. Carbon market

A voluntary market approach appears to be the most efficient path toward carbon neutrality (Kollmuss et al., 2008). When companies begin to transition toward carbon neutrality, the demand for carbon credits will inevitably increase due to their inability to reduce all emissions. The increased demand will drive up prices, and the market will react by creating new carbon sequestration zones (i.e., new businesses will plant forests to sell carbon credits rather than trees). This cycle could repeat up to reaching equilibrium. At any given carbon credit price, companies must assess whether it is financially more advantageous to reduce emissions or invest in carbon neutrality. It appears to be less expensive to invest in forest sinks (Tavoni et al., 2007).

Companies may start buying land in remote areas around the world to create and manage their own carbon sequestration. Since no market is truly voluntary, governments can lend a helping hand in this process to certain industrial sectors or certain sized companies.

This could take shape in many different ways, e.g., governments can set a floor or ceiling price, impose minimum or maximum quotas, or tax based on carbon performance. Given the current political climate and social pressure, it is unlikely that governments will stand aside and allow companies to find common ground to regulate themselves.

Beyond government intervention, carbon neutrality is an instrument companies can use for marketing purposes and to increase demand. Undeniably, consumers are pressuring companies to be eco-friendlier and more responsible. The best way for companies to gain a

competitive advantage from this process is to differentiate themselves from their competitors by opting for a labeling scheme indicating their eco-commitment.

Arguably, once these challenges have been met, companies could create a solid foundation to develop their strategies. Indeed, they could compare their actions to those of competitors, assess whether to reduce or offset emissions, use better energy management tools, and communicate accurate and relevant data to consumers and stakeholders.

6. Conclusion

This research makes several contributions to the literature on sustainability research and practice and the carbon neutrality principle, and is one of the first empirical studies to directly apply the CarbonNeutral Protocol framework. The need for a broader set of practices emerges ranging from carbon footprint reduction to carbon emission offsetting.

Prioritizing sustainable development by reducing emissions is beneficial for the industry: 248 tons of CO₂e to distil 270hl of pure alcohol and reducing the weight of bottles from 710 to 640 grams cuts emissions by 10%. This study is among the first to show that the carbon neutrality principle can offer substantial advantages that far outweigh the cost of maintaining the status quo. A zero-carbon target is feasible with the adoption of the CarbonNeutral Protocol framework. Our findings should thus aid managers in increasing attractiveness without damaging the firm's operational functioning.

Although there are certain limitations in generalizing from a single case (cognac distillery), clear practical implementation can be drawn for other companies in the spirits sector. In addition, the potential legislative changes might accelerate the transition of distilleries to carbon neutral production output.

This study is limited to the context of the French spirits sector. However, greater specificity of the unique context may lead to a better understanding of the industry and the

interplay among different parameters. Our research presents an in-depth investigation, and the revelatory case findings are rich and likely significant for further theory development, in particular with regard to a shift toward carbon neutrality for large spirits conglomerates.

Future studies might refine the analysis to advance sustainable practices and identify the right strategic priorities for launching a carbon neutral product. Finally, this research also argues for further investigation of consumer willingness to pay a premium price for carbon neutral brands.

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