Natural resources and bioeconomy studies 89/2021

Product Environmental Carbon Footprint Report

(Organic Sparkling Wine)

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Ilkka Leinonen and Kati Räsänen

Luke
NATURAL RESOURCES
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Acronyms

PEF = Product environmental footprint

PEFCR = Product Environmental Footprint Category Rules

LCA= Life cycle assessment

CO_2 = Carbon dioxide

CO_2-EQV = Carbon dioxide equivalent, carbon footprint

N_2O = Nitrous oxide

CH_4 = Methane

Summary

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In this work a carbon footprint was assessed by Natural Resources Institute Finland (later: Luke) for one organic sparkling wine product produced in Italy for Vindirekt Finland Oy (later: Vindirekt). Methodically, the work followed the ISO 14040, ISO 14044 and ISO 14067 standards and aimed to follow Product Environmental Footprint Category Rules (PEFCR) calculation guidelines (EU 2018) for the climate impacts to the best of its ability. The PEFCR for wine has been developed in accordance with the requirement provided in the PEFCR Guidance 6.3 (EU 2017) and PEF (EU 2013). Data was collected in one grape farm and winery in Italy from the year 2019. The study covered production of farm inputs, grape cultivation in vineyard, wine making processes in winery, production of packaging and bottling, as well as logistics from Italy to Finland (into Vindirekt's warehouse). This system boundary was later supplemented with downstream stages of the chain: storage, distribution, retail, consumer, and end of life. Climate impact results consisted of fossil CO_2-equivalents (including N_2O, CH_4 and CO_2 emissions).

This report is presenting the main climate impact results with the most essential climate impact sources. The key issues on the assessment methodology and how the study was executed according to Wine PEFCR (EU 2018) will be presented in this report (and when not, clearly reported). Very detailed reporting under PEF was not carried out.

The carbon footprint of the sparkling wine is 1.1 kg CO_2 eq per 0.75L of bottled sparkling wine. Package (glass bottle) production produces the largest share (61%) of the impacts. The second largest share (11%) comes from grape production, of which the highest emissions were from composting the organic fertilizer, N_2O emissions from fertilizer and green manure use, and tractor diesel consumption. The third largest share was from importation (10%) and after this the second fermentation (8%).

Keywords: carbon footprint, climate impact, life cycle assessment, sparkling wine

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1. General

The product was organic sparkling wine produced in Italy.

Vindirekt is a wine importing company located in Helsinki, Finland. It was founded in 1998 and is still owned by the founder. Vindirekt is a contemporary, innovative, and dynamic company that has a team of strongly devoted and experienced specialists. Vindirekt has a carefully selected, world class portfolio from small to midsize producers that create wines of exceptional quality.

In 2016 Vindirekt commissioned a leading sustainability consultancy Gaia to study what actions we can take to improve our impact in the field of sustainability – something that is written in the company's corporate strategy. Understanding the CO2 impact of each stage of the product lifecycle was a major step on our journey of continuous improvement. As a result, we proceeded to create a carbon neutral wine and partnered with the best possible partners: Luonnonvarakeskus LUKE and Corvezzo winery, one of the major producers of organic sparkling wine in Italy. Respecting radical transparency, we will share the results of our project. We hope that it helps the consumers to make better choices and that this is the beginning of new industry standards.

"A GOOD WINE HAS TO BE GOOD FOR THE ENVIRONMENT AND CONSUMERS' WELLBEING AS WELL" – Giovanni Corvezzo

Here at **Corvezzo**, our 100% certified organic winery with over half a century of wine tradition, we pursue every day the goal of "good wine has to be good for the environment". This is thanks to our extraordinary expertise in the delicate art of organic viticulture and sustainable winemaking process.

Giovanni Corvezzo started the full organic conversion of the vineyard in 2010 by completing it in 2017, and today he is the leader of a young and future-oriented team. The knowledge we gained experimenting innovative agronomic techniques for more than 10 years now has made us sector leaders in the production of organic sparkling wine. The family's winery and vineyard (154ha) are located near Venice, between the Dolomites and the Adriatic Sea, a perfect area for producing organic grapes.

2. Goal of the study

The goal of the study was to assess carbon footprint for one organic sparkling wine product produced in Italy for Vindirekt.

The study covered production of farm inputs, grape cultivation, wine production processes, package production and bottling, as well as transportation from Italy to Finland (into Vindirekt's warehouse), storage, distribution, retail, consumer and end of use. Production of infrastructure (machinery, roads etc.) is not included in the study. Detailed reporting of data sets and their quality as required by PEF were not included in the work.

Data was collected in one grape farm and winery in Italy from the year 2019. The role of the Customer was to execute and lead data collection in one grape farm and winery in Italy. Luke provided a data questionnaire (Excel format) for that purpose and supported data collection, with detailed questions related on the grape cultivation, use of inputs and yields, and in the winery and its different process chains as well. The data collection of grape cultivation was carried out from the year 2019.

The assessment work was done from March 2020 until October 2020. The assessment work was done by research scientists Karetta Timonen and Kati Räsänen, senior scientist Juha-Matti Katajajuuri, and research professor Ilkka Leinonen. The project management and data collection work at Vindirekt involved wine retail specialists Joonas Vainio, Vesa Lampi, Meri Dow and Ville Tuomola.

The carbon footprint results of this study will be used to launch a sparkling wine product for the Finnish consumer market. The results will be communicated, marketed, and explained to a broad audience, including consumers, Vindirekt's B2B customers, and to both traditional and social media.

Methodological limitations: the study consisted only of fossil carbon footprint assessment, not any other environmental footprints.

Commissioner of the study is Vindirekt. Verification was done by Gaia Consulting Oy and calculation corrections accordingly. The actual study was carried out by independent research institute Natural Resources Institute Finland (Luke).

3. Scope of the study

3.1 Functional/declared unit and reference flow

According to PEFCR the functional unit is 0,75 litres of packaged sparkling wine.

3.2 System boundary

The chain description and system boundaries of the assessment work are shown in Figure 1: grape cultivation/production, transportation of grapes from vineyard and other ingredients from suppliers to winery, packaging production and their transportation to winery, winemaking process, bottling, the product logistic from Italy to Finland (Vindirekt's warehouse), storage, distribution, retail, consumer and end of life.

Following steps were included:

- **Grape production** which includes the production and transportation of different vine planting inputs (vine seedlings, trellising materials etc.), as well as annual farm inputs (fertilizers, cover crops (green manure), lime, etc.) to the farm. Grape production consists of different processes related with different field operations: vine plantation, plants and soil management, grape cultivation, harvesting and vine destruction.
- **Winemaking process** includes different steps. Firstly, the grapes are **transported** from vineyard to winery by tractor (4t). Other winemaking ingredients are transported with lorry/truck (>32 t, EURO 4), from different suppliers to the winery. Once grapes and ingredients are transported to the winery, grapes are crushed and two co-products are obtained: grape must (used to make the wine) and grape pomace that derivates to the distillation industry to produce spirits, industrial alcohol, etc. The next step in winemaking process after the grapes are crushed, is fermentation and storage. This is followed by filtering and/or clarification, and stabilization. This produces lees, which are also derivate to the distillation industry.
- After the base winemaking process, sparkling wine is obtained by a **second alcoholic fermentation**. This step combines base wine from producer's own winemaking process (utilizing own grapes from the vineyard) with purchased wine from contract supplier. After this second fermentation stage follows a second clarification/stabilization stage, as well as other use of permitted oenological practices (e.g. added SO_2). Finally, the wine is racked (tangential filtration) and bottled under pressure.
- After winemaking process is **bottling** stage, taking into account **packaging production** emissions as well.
- After this, the wine is **transported** 159km from Cessalto to a terminal in Verona (Italy) with lorry/truck (>32 t, EURO 4), which was also expected to return with an empty load. As an intermodal unit, it is routed with train from Verona to Travemünde port (1,290km). From Travemünde, the wine is further transported 1400km with a Finnlines ship to Vuosaari port in Helsinki (Finland), from where it is eventually transported 20km with lorry/truck (>32 t, EURO 4), to the Vindirekt warehouse in Vantaa (Finland). No empty returns or storage of the wine were included.

This study also includes storage, retail, consumer (wine consumption) and an end of life (disposal) stage which are described in Annex I. Also, production of infrastructure (machinery, roads etc.) is not included in the study.

The life cycle stages The Customer have control over are only for its own activities (storage and transportation).

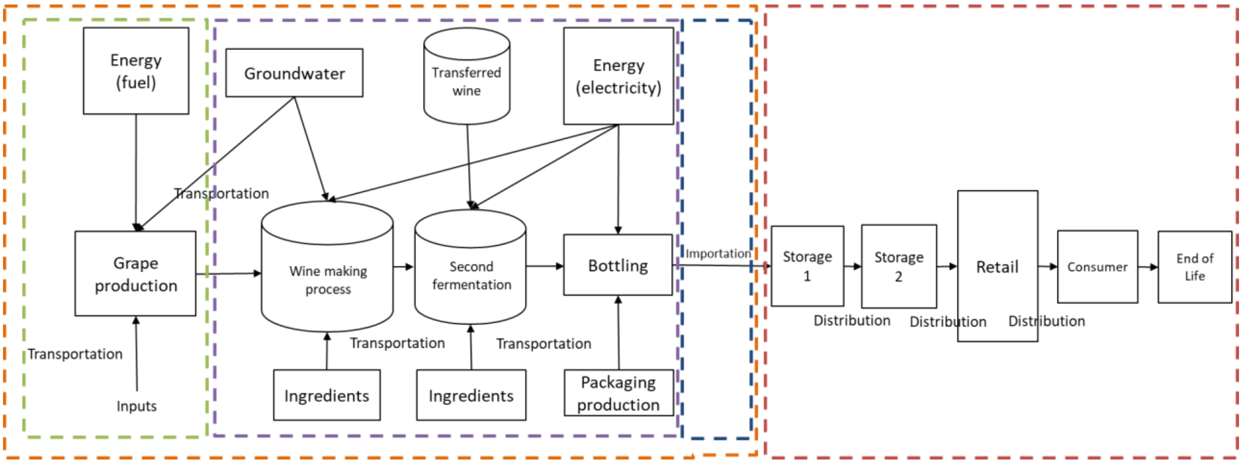

Figure 1. System boundaries of the wine product. The orange describes total system boundaries of the assessment work. The green box describes the cultivation of grapes, the purple box covers winemaking process, second fermentation process, as well as bottling and packaging stage. A blue box means importation product logistics from Italy to Finland. A red box describes the rest of the stages included in the calculations in a follow up project (see more in ANNEX I).

3.3 Environmental Footprint impact categories

The assessed impact category of climate impact included carbon dioxide CO_2, methane (CH_4) and dinitrogen monoxide (N_2O) emissions. The results of the life cycle inventory were characterised using factors suggested in RED II (EU 2018/2001), i.e. CO_2 =1, CH_4 = 25 and N_2O = 298 and presented as carbon dioxide equivalents, kg CO_2 eq. (Munoz & Schmidt 2016).

4. Life Cycle Inventory Analyses

Methodologically, the work followed the ISO 14040, ISO 14044 and ISO 14067 standards. ISO standards describe the method of life cycle assessment at the upper level. In addition, the European Commission's latest PEF (Product Environmental Footprint) guidelines (European Commission, 2013 and 2017) were taken into account and area much more detailed guideline than the calculation and data collection standards, which has become increasingly used. Product Environmental Footprint Category Rules (PEFCR) for still and sparkling wine has been launched in 2018 (European commission 2018) and was chosen because The European Commission is currently strongly advocating that, if environmental footprint calculations for products are to be made public and used publicly, the calculations should be based on PEFCR and in preparation for this visible development. In terms of climate change assessment, the objective is to assess and collect the data according to this PEFCR as accurately as possible. However, very detailed reporting under PEF was not carried out.

4.1. Screening step

No screening step was carried out.

4.2. Modelling choices

Grape production

Data was collected in one grape farm and winery in Italy. The data collection of grape cultivation and winemaking was carried out from the year 2019. The vineyard surface in 2019 was 154ha, and the vineyard soil composition was clay/limestone. The production yield was 18,000kg of grapes per hectare, making a total 2,770 tonnes of grapes in 2019. Cultivation rotation is 25 years.

The following sources of greenhouse gas emissions were taken into account for the carbon footprint calculations:

- Emissions from the production of vine seedlings and materials during vine planting phase
- Organic fertilizer production emissions (composting)
- Emissions from the production of cover crop seeds / green manure
- Emissions from fuel consumption in the transport of vine seedlings and other inputs and materials
- Direct and indirect N_2O emissions from organic fertilizer
- N_2O emissions from green manure use
- Fuel consumption of vineyard machines (incl. emissions from diesel production)
- Emissions from farm water (groundwater) consumption

During vine planting phase, the emissions of different materials were allocated throughout a 25 years' period. In other words, since recurrent 4% due to yearly renewal/substitution, the total emissions of material (trellising materials: vires 250kg/ha, poles 800p (6,000kg)/ha, vine seedlings 3,600p/ha) manufacturing emissions where assumed to be 4% of the total on a yearly base.

The producer uses organic fertilizer in the vineyards (5,000kg/ha/year), with a 2-3% nitrogen content. The product is called "ORGANIC BORLANDA vegetale azotata", allowed by the European Regulation n° 834 BIO (EC 834 BIO), and produced from composted molasses (not from the Corvezzo vineyard). It is transported from a supplier to the farm 5km away by tractor with trailer (empty load included). When assessing the emissions of the organic fertilizer production, we took into account the emissions from composting (IPCC 2006). N_2O emissions derived from the application of organic fertilizer were also taken into account (IPCC 2006).

In addition, cover crops/green manure is cultivated in the vineyard: leguminous (Rye, Triticale, Sativa Oats, protein-rich peas, vetch) and grass (Facelia, Berseem clover, Trifolium, Horseradish, White mustard seeds). These are substituting organic nitrogen fertilizers. Emissions calculation took into account the emissions of seed production (700kg/ha), based on pea seeds emissions in the Ecoinvent 3 database. N_2O emissions derived from the application of cover crops/green manure were also taken into account and calculations were based on hectare-based nitrogen content. To comply with organic regulations, the nitrogen content has to stay below 170kg/ha. Therefore, we assumed the nitrogen content of cover crops must stay around 20kg N/ha, since they are substituting organic fertilizer, and the nitrogen content of organic fertilizer is 150kg N/ha. For N_2O emissions, the value to be used is 0.0157kg N_2O per kg N fertilizer applied (IPCC 2006).

Emissions from manufacturing plant protection products (copper (4kg/ha/year), zeolite (40kg/ha/year), liquid sulphur (50l/ha/year) and poltiglia dispers (12.5kg/ha) were based on the Ecoinvent 3 database.

Emissions per tkm from transporting organic fertilizer with tractor from the supplier (5km away) was based on the Ecoinvent 3. The tractor was also expected to return with an empty load from the vineyard to the supplier.

Emissions from transporting other different materials and inputs (seedlings, trellising materials, green manure seeds, plant protection products) from the suppliers to the vineyard by lorry/truck (>32 t, EURO 4) were based on Ecoinvent 3 data "Transport, freight, lorry >32 metric ton, euro4 {RER}| market for transport, freight, lorry >32 metric ton, EURO4 | APOS, U" excluding vehicle manufacturing, maintenance and road emissions. Empty returns to the different suppliers were not included. Emissions from transporting inputs from the vineyard storage to the cultivation area were included in machinery fuel consumption figures per hectare/year presented in the next paragraph.

The total annual diesel consumption of the machinery in the vineyard was about 490HL. More specifically, during the vine planting phase 14.28 litres per hectare were consumed, and therefore only every 25y (recurrent 4% due to yearly renewal/substitution). Fuel consumptions every year were 7.5l/ha (pruning and cutting), 140l/ha (all year round working), 7.5l/ha (deleaving), 0l/ha (green harvest), 80l/ha (field operations), 28.7l/ha (harvest). Emissions of fuel consumption during machinery work in vineyard were assessed based on diesel consumption emissions of a farm tractor in the Lipasto database (Lipasto 2020). Production emissions of diesel was also included and were based on the Ecoinvent 3.

The producer does not use any heat or electricity for vineyards, with the exception of 6 meteorological stations for the control of humidity and temperature in the different areas of vineyards. These are powered by their photovoltaic plant. However, data on their solar energy production and consumption figures on vineyards were small and was included in the energy consumption data for winemaking process and second fermentation process assessments.

1,540m^3 (tonnes) of groundwater was used in 2019. Grape production did not involve the usage of public water, as it is allowed only during draught period. Even then the producer would use water from nearby canals, not from pipelines. Emissions were based on the Ecoinvent 3 for "Tap water (groundwater without treatment)".

The waste streams (vegetable waste from the vineyards) were truck loaded and taken to a composting company (different than the one producing organic fertilizer) 35km away, to produce biomasses for other operators. Therefore, the emissions from grape cultivation waste treatment in the composting company were excluded from the system boundaries.

Winemaking process/vinification

The winemaking in 2019 produced 23,000 HL of wine per year from the producer's own vineyards (154 ha) and 7,000 HL of wine was purchased from elsewhere, making it total 30,000 HL of wine produced in 2019. Of this total amount of wine produced, 18,750 HL (62.5%) was processed into sparkling wine.

The carbon footprint for wine processing took into account the following sources of greenhouse gas emissions:

- Carbon footprint of grapes (grape production)
- Production emissions from other ingredients
- Transportation emissions of grapes and other ingredients
- Consumption of energy during winemaking process, bottling and storage (including emissions from energy production)

Production emissions of different oenological ingredients (bentonite clay (10g/HL), yeast (200kg/year) and soda and citric acid (124kg/year), pectolytic enzyme (2ml/HL)) were based on the Ecoinvent 3 database.

The emissions from transportation of grapes from the vineyard storage to the winery by a tractor with trailer were included based on the Ecoinvent 3 data. Empty return from winery to the vineyard was included. Also, emissions from transporting other ingredients from suppliers to the winery by lorry/truck (>32 t, EURO 4) were based on the Ecoinvent 3 data "Transport, freight, lorry >32 metric ton, euro4 {RER}| market for transport, freight, lorry >32 metric ton, EURO4 | APOS, U" excluding vehicle manufacturing, maintenance and road emissions. Empty returns to the different suppliers were not included. The tractor and semi-trailer truck were also expected to return with an empty load from the vineyard.

Energy consumption during the wine production was given only as a total annual energy consumption value. It was assumed that 60% of this was for base wine making process. Producer used electricity (189,000kWh/year*0.6) from it's own photovoltaic system, for which the Ecoinvent 3 database for solar energy emissions in Italy was used. Producer also purchased electricity (593,670kWh/year*0.6), of which renewable 41%, natural gas 39% and fossil energy (oil) 20%. Also, for this the Ecoinvent 3 database emission factors for electricity based on same shares for renewable, natural gas and fossil energy produced in Italy were applied.

The water consumption during wine making process, second fermentation and bottling was 1500 HL per year. Of this, the share for wine making process (lots of dedicated machinery + many vessels that need to be washed) was 196 HL. For the emissions for water consumption, the Ecoinvent 3 database for "Tap water {Europe without Switzerland}| tap water production, conventional treatment | APOS, S" was used.

There was no heat consumption. Producer was using running cold water for all cleaning purposes in the winery during the winemaking process.

Grape pomace and lees from the winemaking process were delivered to distillery and not considered as waste. In this study, according to the producer, the weight for pomace was 300 tonnes, lees 67 tonnes and wine 2,300 tonnes. Therefore, the emission allocation values in this work are: 86% for wine, 11% for pomace and 3% for lees.

Second fermentation

According to the producer, 18,750HL (62.5% of total amount of wine produced in 2019) were processed into sparkling wine (autoclave cycles, etc.). This second fermentation process consists of 14,375HL (23,000HL * 0.625%) of wine from their own hectares and vinification process, and 4,375HL (7,000HL * 0.625%) purchased organic wine.

The carbon footprint for secondary fermentation took into account the following sources of greenhouse gas emissions:

- Carbon footprint of base wine (14,375HL)
- Carbon footprint of transferred organic wine (4,375HL)
- Production emissions of ingredients
- Consumption of energy during second fermentation process (including emissions from energy production)
- Transportation emissions of transferred wine and other ingredients

The estimate for climate impact for transferred organic bulk white wine (4,375HL) was assessed to be in average 0.291kg CO_2 eq per litre. This was based on emission value (0.224kg CO_2 eq per 0.75l) studied by Petti et al. (2006) for organic white wine produced in Italy, as well as on the emission value (0.283kg CO_2 eq per litre) for organic base white wine produced in Corvezzo winery (this was also assessed during the modelling for sparkling wine in this case study). The latter value was used, since the transferred wine was produced also at an organic farm and only 5km away, therefore considered to have in average similar level of emissions. Both emission values were for bulk wine only, meaning they do not assess the second fermentation, bottling, package production, delivery, (and) or consumption stages. There is quite a dispersion and variation in the literature LCA results to be found at this moment for conventional/organic red, white or sparkling wine, and it was challenging to find a study for organic white (bulk) wine produced in Italy excluding second fermentation, bottling and package production (e.g. Fusi 2014, Vazquez-Rowe et al 2013, Benedetto 2013).

Production emissions of different ingredients during second fermentation process: SO_2 (6kg/year), sugar cane (66,185kg/year), yeast (400kg/year), soda and citric acid (50kg/year) were based on the Ecoinvent 3 database.

Emissions from transportation of other ingredients from factory to the winery by lorry/truck (>32t, EURO 4) were based on the Ecoinvent 3 data “Transport, freight, lorry >32 metric ton, euro4 {RER}| market for transport, freight, lorry >32 metric ton, EURO4 | APOS, U” excluding vehicle manufacturing, maintenance and road emissions. The semi-trailer truck was also expected to return with an empty load from the vineyard.

Energy consumption was given only as a total annual energy consumption value. It was assumed that 40% of this was for second fermentation production. Producer used electricity (189,000kWh/year*0.4) from its own photovoltaic system, for which the Ecoinvent 3 database for solar energy emissions in Italy was utilized. Producer also purchases electricity (593,670kWh/year*0.4), of which renewable 41%, natural gas 39% and fossil energy (oil) 20%. For this the Ecoinvent 3 database for electricity emissions in Italy (Electricity, medium voltage {IT}| for consumer | APOS, U) was used. Behind this emission factor Ecoinvent 3 emissions factor (Electricity, high voltage {IT}| market for | APOS, U) was applied based on same shares, for renewable, natural gas and fossil energy.

The second fermentation consumed water 84HL per year. For the emissions for water consumption, the Ecoinvent 3 database for "Tap water {Europe without Switzerland}| tap water production, conventional treatment | APOS, S" was used.

There was no heat consumption during second fermentation process. Producer is using running cold water for all cleaning purposes in the winery.

According to producer, the weight of lees from secondary fermentation is 2 tonnes, and wine 1870 tonnes. Therefore, the emission allocation values for wine is 99.9% and for lees 0.1%.

Bottling and packaging production

In case of bottling stage the company-specific activity data to provide include: the list of materials (ingredients) used, energy consumption (LPG) and water consumption (m^3).

The carbon footprint for bottling took into account the following sources of greenhouse gas emissions:

- Emissions from LPG use (production of LPG)
- Emissions of water consumption
- Carbon footprint of sparkling wine bottle

Bottling consumes water about 1,220HL/year (bottle washing, machinery cleaning and sanitizing and bottle warming). For the emissions for water consumption, the Ecoinvent 3 database for "Tap water {Europe without Switzerland}| tap water production, conventional treatment | APOS, S" was used.

Heat was utilized only in the bottling area, where steam is used to clean and sanitize and warm water to warm up bottles before labelling. Steam was produced with electricity (summed up with 2nd fermentation), and the warm water was produced with an LPG system – 16,345kg consumed in 2019. For liquid petroleum gas emissions, the Ecoinvent 3 data was used.

The packaging production and transportation from a bottle supplier to winery was included in this assessment. The applicant did not have any information about the carbon footprint of the bottle they use. In this study, the used 540g (recycled content 85%) glass bottle's climate impact of 0.675kg CO_2eq per litre was applied (Gaia Consulting Oy 2018). Therefore, it is further estimated that the climate impact of a 720g glass bottle was 0.900kg CO_2eq per litre and 0.675kg CO_2eq per 0.75L (bottle). According to Gaia Consulting Oy (2018) the system boundary includes production and raw material supply for primary packaging (bottle), closure and label. Raw material transportation to bottle closure and label production was included as well as transportation of bottles, closures and labels to filling stage.

As for the secondary packaging the climate emissions of corrugated cardboard per one bottle of sparkling wine were assessed. For this we applied fossil emissions of 718kg CO_2 equivalents per tonne of corrugated packaging (Fefco 2019). Therefore, the emissions for one cardboard case (light case weight 200 g) is 0,144kg CO_2 eq and only 0,024kg CO_2eq per one bottle (6 bottles per case). However, it excludes the end of life stage (EoL) and since the cardboard for Think-wine is assumed to be recycled the inclusion of EoL stage would decrease the emissions even further. In addition, plastic consumed in packaging and transportation is 200 g per full pallet including 96 cases and 576 bottels making it only 0,35g of plastic film per bottle. By using Ecoinvent emission factor "Extrusion, plastic film {GLO}| market for | APOS, U" the emissions of plastic film for one bottle is only 0,0001 kg CO_2ekv. per 0,75l (less than 0,01% of the total carbon footprint and therefore insignificant).

Transport

The careful estimate for the load sales item transported to Finland was 7,000-10,000 bottles per year. Making it in average 8,500 of bottles and 6,375 litres or kilos of wine per year transported to Finland. In addition, 8,500 glass bottles weighting 720g each, making it total 6,120kg. All in all, this makes total 12,495 kilos of bottled sparkling wine transported to Finland.

According to the importer, their logistic partners in Vantaa (Finland) uses two transportation options depending on the available transport capacity. In this study, the most common scenario was assessed: emissions from transporting wine from the winery in Cessalto to the terminal in Verona, as well as from Helsinki (Finland) to the warehouse in Vantaa (Finland) by lorry/truck (>32 t, EURO 4) were based on the Ecoinvent 3 data "Transport, freight, lorry >32 metric ton, euro4 {RER}| market for transport, freight, lorry >32 metric ton, EURO4 | APOS, U" excluding vehicle manufacturing, maintenance and road emissions. There were no empty returns. As an intermodal unit, it was routed from Verona with a freight train to Travemünde port (1,290 km) based on the Ecoinvent 3 data. The emissions from transporting the wine from Travemünde to Vuosaari port in Helsinki (Finland) with transoceanic freight ship (Finnlines) was also based on the Ecoinvent 3 data, excluding vehicle manufacturing and maintenance emissions. There were no empty returns.

Storage, distribution, retail, consumer and end of life

Previously mentioned stages were complemented in a follow-up project with emissions from storage, distribution (logistics to retail), retail, consumer use, and waste treatment (end of life). This complementary work is presented in a more concise manner in ANNEX I.

Biogenic emission and emissions from land use change

This study did not assess biogenic emissions or carbon stored in grapevines and the soil. However, according to PEFCR vineyards are not expected to be a major producer of methane. According to PEFCR, carbon permanently stored in the soil and tree biomass of cork oak forests and vines shall be taken into account only if this storage goes beyond 100 years. Also, only biogenic carbon that vines and/or cork oak remain accumulating after the 100-year assessment period shall be calculated. However, the cultivation cycle for grapevines with this case study is only 25 years and the land has been in vineyard and agricultural use over the last 40 years. Also, the expansion since 2014 has been made on existing organic (or under organic conversion) vineyards, and no farmland/forest has been reclaimed.

4.3. Handling multi-functional processes

According to PEFCR, the allocation of co-products (grape must and grape pomace, as well as wine and lees) shall be conducted as physical allocation. The mass of the different outputs shall be used to allocate grape production and transportation and wine making process until the separation of lees. According to PEFCR typical values are: 80% for wine, 19% for grape pomace and 1% of lees.

In this study, during vinification process the weight of pomace was 300 tonnes, lees 67 tonnes and wine 2,300 tonnes. Therefore, the values in this work during vinification calculations are: 86% for wine, 11% for pomace and 3% for lees.

During second fermentation process the activity data regarding the weight of the different co-products shall be used to apply these allocation rules. According to producer the weight of lees from secondary fermentation is 2 tonnes and wine 1,875 tonnes. Therefore, the values for wine was 99.9% and for lees 0.1%.

4.4. Data collection

Data was collected in one grape farm and winery in Italy from the year 2019. The role of the Customer was to execute and lead data collection in one grape farm and winery in Italy. Luke provided the data questionnaire (Excel format) for that purpose and supported data collection, with detailed questions related on the grape cultivation, use of inputs there and yields and in the winery and its different process chains as well.

Primary data was used when available and if not Ecoinvent 3 database was utilized.

According to PEFCR, because grape production is under control of the applicant, the data of following processes was considered as company-specific activity data: production yield (kg of grape per ha), amount of products applied in the vineyard (plants and soil) (kg and m^3 for liquids), amount of water used (m^3), amount and type of energy used (kWh and m^3 for fuels), amount and type of tying materials used (kg), and vineyard surface (ha).

For winemaking and second fermentation, the company-specific activity data included the list of materials (ingredients) used, energy consumption (kWh), water consumption (m^3) and waste generated.

In case of bottling stage, the company-specific activity data included: the list of materials (ingredients) used, energy consumption (LPG) and water consumption (m^3).

For the different transports of different inputs and materials, the applicant, as well as a logistics partner provided company-specific data about: transport mode, distance per transport mode (km), utilisation ratios for truck transport (%), and empty return modelling for truck transport.

5. Impact assessment results

5.1. PEF results

The fossil carbon footprint of bottled sparkling wine when distributed to Finland was 1.1 kg CO_2eq per 0.75L (bottle). The emission shares (%) for distributed sparkling wine are shown in Figure 1.

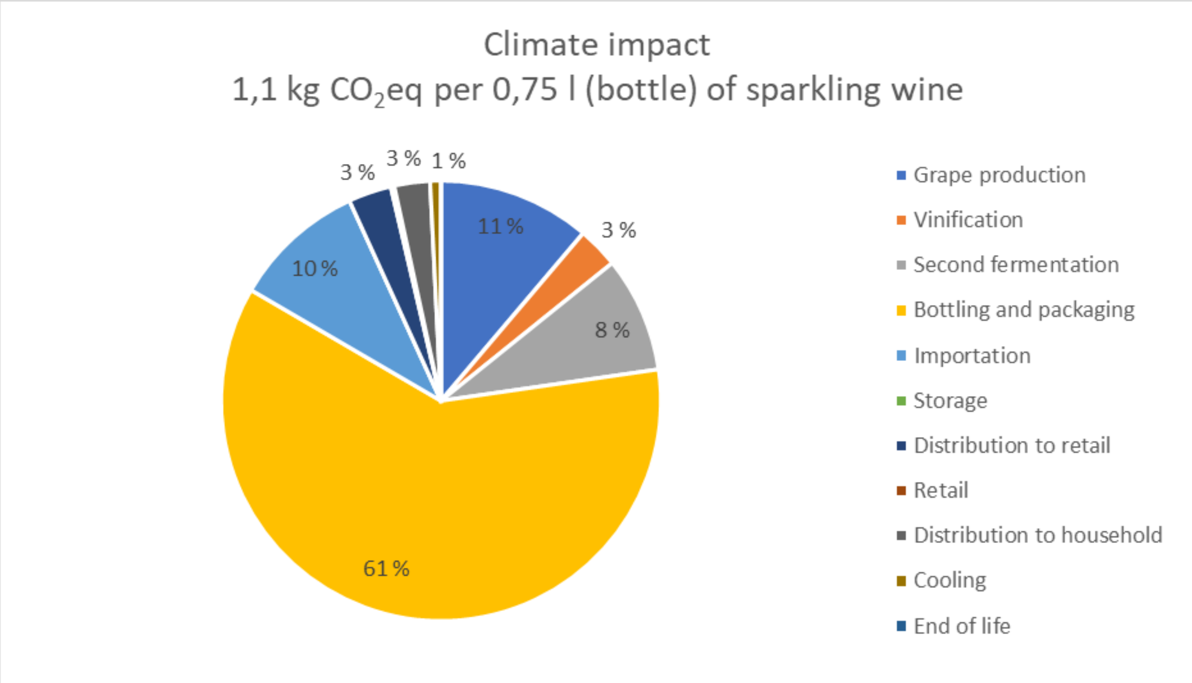

Figure 2. The emission shares of organic sparkling wine carbon footprint.

5.2. Interpreting carbon footprint results

Bottling and package production (including secondary packaging) made the biggest share (61%) of the impacts, and the package production made almost all (99.9%) of this. According to PEFCR, the impact share for sparkling wine packaging is 41%, but in this study the share is greater due to more sustainable cultivation and vinification practices (e.g. organic fertilizers and renewable energy use). In order to decrease environmental impacts during bottling and packaging, the recycle rate of used glass bottle should be even higher, or the glass bottle should be lighter. However, in case of sparkling wine, a too light glass bottle may be a risk of consumer safety and/or lead to product loss. In addition, sparkling wine cannot be packaged in a PET bottle. In both cases the far lighter bottle cannot withstand the pressure.

The emissions share for organic grape production was 11% of the total carbon footprint. The highest emissions during grape production stage was composting of organic fertilizer (26%), farm tractor diesel consumption (22%) and N_2O emissions from fertilizer and green manure use (21%). Organic fertilizers utilized in vineyard were composted only 5km away, and they were substituting mineral fertilizers, which generally reduces emissions since nutrients are re-cycled. Also cover crops/green manure was substituting mineral fertilizers. There was no liming, which further reduces CO_2 emissions. Waste streams were all considered as raw materials with zero emissions (with no market value) and composted in a company elsewhere making biomasses for other operators and therefore waste management emissions were excluded. Water utilized was groundwater without treatment. There was no electricity utilized during grape production. Manpower was very commonly used in the vineyards and was partly substituting machinery work and diesel consumption. In order to decrease environmental impacts even more during grape production, the fuel consumption should be decreased. If not possible, the next option would be to substitute fossil diesel with biogas or third- and second-generation biodiesel. In addition, a higher yield level would lower the emissions per kg of grapes even more, but with the case of grape production higher yields will probably lead to inferior wine quality.

Logistics (importation) to Finland was 10% of the total emissions. Sparkling wine is already bottled in Italy and therefore transported weight is greater than wine with lighter package (e.g. bulk wine). This leads to greater emission shares for the logistics than with lighter package per litre if wine e.g. bulk wine. In order to decrease environmental impacts during logistics, the wine should be with lighter package (e.g. bulk wine), however, this is not the possible case with sparkling wine. In addition, the fuel source for vehicle/transport mode should be from renewables.

Second fermentation (8%) included purchased wine produced elsewhere. The highest emissions were from manufacturing the purchased wine (52%), as well as electricity (43%) used. Electricity utilization was based either on solar energy produced in the farm or purchased energy, which, meaning altogether 55% of electricity was from renewable sources. In order to decrease environmental impacts even more during vinification, increasing the share of renewable energy is suggested.

Emissions during the wine making (vinification) process were only 3%. The highest emissions during vinification were from electricity use (96%). Electricity utilization was based either on solar energy produced in the farm or purchased energy which, meaning altogether 55% of electricity was from renewable sources. In order to decrease environmental impacts even more during vinification, increasing the share of renewable energy is suggested.

The results from the follow-up project assessing downstream of the chain revealed that the emissions from storage and retail were almost zero and insignificant. Emissions from distribution to retail by different logistic companies were 3%. Consumer use (including distribution to household is and cooling the product) is altogether 4%. Emissions and their calculations methods are presented more precisely in Annex I.

For sensitivity analyses, it was studied how emissions would change if consumer stores sparkling wine only 24 hours on average in the fridge until wine is completely consumed, the carbon footprint emissions decreased from 1.148 kg CO_2eq per 0.75l of sparkling wine to 1.140 kg CO_2eq per 0.75l of sparkling wine which is 0.7% decrease of the total emissions. If consumer stores the sparkling wine for 100 days instead of 7 days, the carbon footprint increases from 1.148 kg CO_2eq per 0.75l of sparkling wine to 1.267 kg CO_2eq which is 10.4% increase of the carbon footprint emissions. The sensitivity analysis would have been performed primarily for the bottle, but there were not enough project resources for a total new modelling of a bottle production chain and waste treatment.

It is important that the carbon footprint estimates of wines are made according to PCR, as this study has been done, which can provide comparable results in the future follow-up. There are considerable variations in the current carbon footprint calculations, which is not clear if it is due to variations in different production methods, packaging, or calculation methods.

It is also good to remember and be aware that the carbon footprint does not take into account all the benefits and advantages of organic production. In the future, it is good to highlight other environmental impacts as well e.g. eutrophication and biodiversity impacts.

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Annex I

The emissions from storage, distribution (logistics to retail), retail, consumer use, and waste treatment (end of life) were calculated also. As the case product is still a new product and annual data is not available, data from one month (May 2021) was taken as the reference month, with emissions scaled to annual level.

There was no company specific data to be received concerning ambient **storage** (VD) energy consumption for sparkling Think -wine before distribution to Alko storage. However, according to PEF and Zampori & Pet (2019) ambient storage area is approximately 24,000 m^2 (80% of 30,000 m^2) and it stores 2,496,000 m^3 of product in a year, in other words 104 m^3/ m^2 a year. The average ambient storage energy consumption is 30 kWh/ m^2 year and 360 MJ bought (= burnt in boiler) or 10 N m^3 natural gas/ m^2 year (if using the value per, do not forget to consider emissions from combustion and not only production of natural gas). It was assumed that storage can hold 400 bottles of wine per m^3. In addition, 365 m^3 of water is used per year as a total for activities such as cleaning, lawn irrigation, etc.

We estimated the energy consumption to be approximately 0.0007 kWh/0.75l (bottle of wine) and heat consumption 0.0087 MJ/0.75l (bottle of wine) per year. Water consumption is only $2.9*10^{-7}$ m^3 per 0.75l (bottle of wine). Emissions from electricity production are based on modelling of Finnish electricity production in Luke. This modelling is based on the Finnish Energy (ET) statistical data (Finnish Energy (ET) Electricity Statistics) on the structure of Finnish electricity production in 2020. A report on losses in electricity distribution networks is based on Honkapuro et al. (2015). Carbon dioxide emissions and production efficiencies from combustion-based energy production are based on Statistics Finland's statistics (Statistics Finland Energy Statistics) and specific emissions from fuels (Statistics Finland fuel classification 2020). Emissions from heat usage is based on statistical data in 2019 (Finnish Energy (ET), Statistics Finland's Energy Statistics) and for heat production a specific emission factor +10% is applied. Emissions of water consumption were based on Ecoinvent emission factor "Tap water {Europe without Switzerland}| tap water production, conventional treatment | Cut-off, U".

Vindirekt's own **distribution** of wine leaves from ME-Group Vantaa to Alko central warehouse and the distance is approximately 3.5km. The route is part of bigger logistic chain and there are no empty returns. The vehicle load factor is 2.8 tons. To transport the bottles, 15 shipments (1–4 cases at a time, 6 bottles per case) are made to the warehouse. The load weight is 1.5kg per bottle of wine and 0.2kg for a case weight (0.2kg/6 bottles is 0.033kg per bottle). This study utilized Ecoinvent emission factor per tkm "Transport, van <3.5t/RER U" including diesel supply but excluding construction, maintenance and road emissions.

Alko storage (AKVA) is not included in the calculations since the wine stays there only for a short time before taken almost immediately to the retail.

During May there were altogether 206 bottles of Think sparkling wine **distributed** to 13 stores. Monthly drives were thought to roughly reflect each month of the year and were scaled to an annual level. Transportation of 198 bottles (per month) to the retail sector (Alko stores) is done by two distribution companies and the remaining 8 bottles are sold through Alko's web shop.

> Concerningthe **distribution** of 126 bottles to 8 stores we received transport company specific data on emissions factors (kg CO_2eq/freight) that were calculated by the company and based on data about transport mode, – distance per transport mode (km), – utilization ratios for truck transport (%), and – empty return modelling for truck transport. The distances were based on EcoTransIT methodology and emission calculations comply

with the ISO 14064 and EN 16258 standards. We also received company specific data on the amount of Think-wine bottles per each store transported.

For the second distribution company (5 stores, 72 bottles) we received company specific data on transportation distance estimate of 1555.1 kilometers per month (5/2021). Consisting of 5 deliveries and vehicle of 12 tonnes. The average fuel consumption of the vehicle is 28 liters/100km. The emission factor for diesel consumption is 2.53 (tank-to-wheel) (kg CO_2eq/liter). In other words, a vehicle consumes a total of 435.4 liters of fuel/1555.1km per month, making the total emissions 1.101 tonnes CO_2eq per month (5/2021). Emissions data is from tank-to-wheel and does not include diesel production so therefore we assessed it here separately using Ecoinvent emission factor for diesel production 0.526kg CO_2eq /kg (Ecoinvent 3, Europe without Switzerland, market for, APOS, U) and density of diesel 0.845 kg/l (Alakangas 2000).

Distribution for the remaining 8 bottles into Alko web shop storage was assessed by using same emission estimations per bottle of wine than with Vindirekt's distribution to storage (AKVA).

According to PEF and Zampori & Pet (2019), for **retail** specialized in food/ beverage products a 400 kWh/m^2/year for the entire building surface is to be considered (not including chilled and frozen storage). An average retail place is assumed to store 2,000 m^3 of products (assuming 50% of the 2,000 m^2 building is covered by shelves of 2 m high) during 52 weeks, i.e. 104,000 m^3 * weeks/year. Therefore, one m^2 area is assumed to store 52 $m^3$of product per year. There are 400 bottles of wine per m^3. Therefore, energy consumption is assessed to be approximately 0.019kWh per one bottle (0.75l of wine). We used emission factor for average Finnish electricity (see previously presented methodology of electricity on storage assessment). In addition, 3,650 m^3 of water is used per year as a total and the water consumption per bottle in a year is approximately assessed to be only $8.7*10^{-5}$ m^3 per 0.75l (bottle of wine). Emissions of water consumption were based on Ecoinvent emission factor "Tap water {Europe without Switzerland}| tap water production, conventional treatment | Cut-off, U".

Applying PEFCR guidelines for assessing **distribution from retail sector to the consumer** is divided in specific proportions between Ecoinvent 3 data "Transport, passenger car, EURO 3 {RER}| transport, passenger car, EURO 3 | Cut-off, U", "Transport, freight, lorry 3.5–7.5 metric ton, EURO3 {RER}| transport, freight, lorry 3.5–7.5 metric ton, EURO3 | Cut-off, U".

According to PEFCR the energy consumption for **cooling of the product** before its consumption is 0.0037 kWh/l/day and 7 days of storage in the fridge until wine is completely consumed shall be applied. When calculating the energy consumption, the volume occupied by the product in the fridge shall be considered. It is assumed that the storage volume is 3 times the packaged volume (e.g. 0.75 l of wine (still or sparkling) requires 2.25 l of storage volume in the fridge). More specifically, according to PEFCR (table 20) electricity consumption is 0.062 kWh per FU (0.75l of wine). We used emission factor for average Finnish electricity (see previously presented methodology of electricity on storage assessment).

No additional calculation is required on **waste treatment and recycling of the bottle**. The emissions of packaging (bottle for sparkling wine) is already included in published carbon footprint by Timonen et al. (2019) and utilizes emission calculations of Gaia Consulting Oy (2018). The emission factor used is "Packaging glass, green {RER w/o CH + DE}| production | Cut-off, U" which includes collection and sorting and therefore the largest part of the glass cycle is already included. With regard to the rest of the material, and also possible emissions from the small amount that does not go for recycling in Finland, it can be assumed that it will go to the 5% without further calculation.

According to wine PEFCR **5% consumer loss** has to be included, but in this case, it does not need to be taken into account. This is because, even if the consumer would theoretically throw away 5% of the product it does not directly increase emissions at the system level, and Vindi-rekt's offsets/compensates the emissions throughout the chain, including the part that might be wasted.

Table 1. The emissions of organic sparkling wine (kg CO_2eq per 0.75l of sparkling wine).

Stage		CO_2eq	
Grape production		0,128	
Wine making	Vinification	0,034	
	Second fermentation	0,097	
Bottling and packaging		0,699	
Importation		0,112	
Storage		0.000	
Distribution		0.036	0.010 of this already compen-sated by one distribution company
Retail		0.003	
Consumer	Distribution	0.030	
	Cooling	0.009	
Carbon footprint of sparkling wine		**1.148**	
		1.138	Result excluding compensated emissions

Annex 2

Critical review statement of Carbon footprint of organic sparkling wine

Title of the study: Product Environmental Carbon Footprint Report (version 1.1) (Organic SparklingWine)

Commissioner of the LCA study: Vindirekt Finland Oy

Practitioners of the LCA study: Karetta Timonen, Juha-Matti Katajajuuri, Ilkka Leinonen and KatiRäsänen, Natural Resources Institute Finland (Luke)

Reviewers: Pauliina Saari and Magda Horváth, Gaia Consulting Oy

Scope of work

We have been engaged by Vindirekt Finland Oy (the Client) to review the report of Product Environmental Carbon Footprint Report. The report describes the calculation and results of carbon footprint for Think Organic sparkling wine. The functional unit of the study is "0,75 litres of packagedsparkling wine".

Carbon footprint is calculated following the ISO standards for LCA (ISO 14040 and 14044) and product carbon footprint calculation (ISO 14067). Furthermore, the requirements and guidelines ofPEFCR for still and sparkling wine (EPD International®) concerning functional unit, system boundaries, cut-off criteria and allocation rules are followed in the study.

The critical review was performed according to the requirements of ISO 14044 (section 6.2) and ISO/TS 14071:2014. The review was performed after the study was completed. The review was based only on the data presented in the study report. The review did not include the assessment ofthe LCI model or the analysis of individual data sets (calculation files).

The critical review process shall ensure that

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

Conclusion

When reviewed against the standards and guidelines described above, nothing has come to our attention that causes us to believe that the carbon footprint calculations for the product under revieware not performed and reported according to the requirements and guidelines followed.

We present our detailed findings and recommendations as part of separate documentation.

This verification statement is based on the terms and conditions of our engagement. We are accountable for our work, this verification statement and our conclusions to the Client only, not to thirdparties.

Helsinki, November 10, 2021

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