LIFE CYCLE ASSESSMENT OF WINE PRODUCTION PROCESS:

FINDING RELEVANT PROCESS EFFICIENCY AND COMPARISON TO ECO-WINE PRODUCTION

1N1800 LIFE CYCLE ASSESSMENT

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GROUP 4

2006 MAY

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ABSTRACT

This report analyses the life cycle of the production of wine, from the raw materials input at the vineyard operations all the way to the disposal and even recycling of the glass bottle. The objectives focus on finding the main impacts of the wine life cycle, as well as identifying crucial activities/stages in the wine production which establish the largest impacts. Moreover, there is a new product emerging on the market, the ecological wine (or organic wine). By comparing the normal wine life cycle and eco-wine life cycle, the real nature of ecological wine can be judged. In other words, if it is correct to add an eco-label to eco-wine.

Different aspects can be underlined in the study; first of all, fossil fuels produce the worst impact category, but there is no key stage that is responsible for this impact. The three main stages, however, Wine production, Glass production and Transport have similar accountability in both overall and fossil fuels impact in the environment. Nevertheless, it is difficult to improve the wine life cycle by focusing merely on the transport and glass production. The former depends highly on the distance, and the later is a fixed process. Therefore, improvements in the wine life cycle should centre on the Wine production. Data collected contains many assumptions based on the relative deficiency of prominent data available, many of these assumptions for which were produced by the investigating team.

Ultimately, eco-wine is considered to be an eco-friendly alternative for Wine production. The results defend this point, and although ecological wine doesn't hold the greatest decrease in impacts to the environment, it can help to alleviate the impacts and promote sustainable agriculture for future wine endeavours.

INTRODUCTION

The production of wine is indeed a process of complex nature, from the initial wine grape nurturing at the vineyard to the winery activities to extract the juices from these grapes. To what extent do these activities consume energy and produce emissions, however? In the past this area of beverage production has not come under much scrutiny as far as environmental loads, due to the nature of its resources and production. Therefore, the life cycle of wine will be explored to further detail stages in the process of concern and to provide areas of improvement in account of sustainability to health and the environment.

In recent years, new product on the market, ecological wine (or organic wine) has been emerging with quite rapid success, along with many other organic foods which now see popular demand. But, what exactly makes eco-wine more fashionable? Upon the mere mentioning of the term “eco-wine,” a reaction from many of the general public is of conundrum and concern. This follows by the words, “what is it, and what makes it different?” Consequently, a thrill to learn more ensues. Wine is indeed a drink of luxurious and social status, and the assumption that a particular wine is of environmental concern only adds to the novelty and conversational value associated with its consumption.

OVERVIEW OF THE WINE PRODUCTION PROCESS

Wine production is a technique of great regard and complexity to produce a beverage enjoyed worldwide. The process begins at the vineyard, where wine grapes using special techniques for cultivating and maintaining the crop, depending upon the species of grape and type of wine associated. Thereafter, the grapes are harvested, upon which they are then either extracted of their juices, called the must, in a process called crushing either mechanically or by treading, the traditional method of basically stepping on the grapes in a large container. Red wines, as described in this report, are fermented with their skins and pips, from which alcohol that is produced during the fermenting process will begin to extract colouring and tannins of the skins and seeds, giving wine its colour. Fermentation commences by adding the juices and skins together, which contain natural yeasts then producing alcohol and carbon dioxide. Henceforth, the wine is then introduced into a series of processes called clarifying where the skins and other debris are filtered, fined and kept at constant temperature. Hereafter wine undergoes measures to ensure that the wine will not spoil and produce haze, called stabilization by addition of chemicals and constant temperature storage. Wine must then be aged for some time, in a process named aging, and thereafter bottled and transported to the end user. The whole process can take considerable time, from several months to years depending upon the degree of quality to be achieved. (Wine:Made How, 2006)

LIST OF TERMS USED

Vineyard- The farm where wine grapes are grown for wine production

Wine grapes- Special grapes used for wine production

Viticulture- The science, cultivation and study of grape growing.

Fermentation- The process by which grape sugar turns into alcohol and carbon dioxide

Winery- A winery is a facility where fruit, usually grapes, is processed into wine. Some wineries are located on the same site as the vineyard whose grapes they process, while others process grapes they purchase from vineyards many away from their production site.

Clarification- umbrella term for a host of processes designed to ensure wine is crystal clear, including fining, filtration and refrigeration.

Treading(Crushing)- an important winemaking operation involving literally pressing the juice (white wines) or astringent press wine out of the skins.

Stabilization- umbrella term for all the winemaking operations designed to stop wines developing a fault in bottle such as a haze, cloud or fizz, no matter what the storage conditions. It is practiced most brutally on everyday wines.

1 OBJECTIVES

1.1 GOALS FOR THE ANALYSIS

From the details and data associated with the production cycle in the wine production industry, a life cycle assessment shall provide information on relevant impacts to environment, human health and more of wine production. The contributions of each sub-process is of great importance in order to classify wine and know the areas which create the most problems, to be later compared and discussed about with further context to a new type of wine, ecological wine or organic wine.

Subsequent to the investigation into the life cycle of regular wine production, the ecological variety will be compared, not with numbers, but by the areas which it employs as a way to reduce impacts to the environment. Shortcomings in the process of regular wine will be thus compared with areas of highlight for ecological wine, and the efficiency of each stage justified. Therefore, the following report wishes to conduct an assessment of whether or not an ecological product, such as wine, is truly more sustainable or comparatively equal to its normal counterpart. The report also aims to identify whether the labelling of “ecological” wine is fair to class, while the regular wine will be compared, in turn, to assess its impacts and possible similarities with an ecological product.

In retrospect, the specific aims of this report shall include:

- ❖ Extent at which activities consume energy and introduce emissions in wine production
- ❖ Identify the crucial activities/stages in the wine production which establish the largest impacts
- ❖ Classify which activities ecological wine aims to explore to reduce impacts
- ❖ Judge the true nature of ecological wine in respect to regular wine

1.2 TYPE OF LCA

In the particular case of wine production life cycle assessment for this investigation, the class into which it should fall is known as a *Stand Alone LCA*. It is mentioned above, that a variety of wine will be contrasted to that which will have the LCA analysis. However, due to the very small amount of data available on ecological wine, only the life cycle assessment of regular wine shall be conducted. Subsequent to this, as mentioned above, comparison shall be based on activities associated with each product. Consequently, no comparison data on LCA of the two is sought after in this report and the stand alone option is of best regard.

1.3 APPLICATION AND AUDIENCE

A life cycle analysis of wine production will not only show the environmental impacts associated with its complex cycle, but also aim to build upon these downfalls and provide relevant positive outputs of each to be delivered to their respective audience.

Application of this report shall address and convey information to two categories of audience, those being the Wine Producer and the General Consumer.

Information to the Wine Producer shall concentrate on:

- ❖ Increasing knowledge on product's environmental strengths and weaknesses
- ❖ Product and Process development areas, their environmental assessment, aspects and efficiency possibilities
- ❖ Providing information to market place with further details on environmental management systems in place
- ❖ Conveying a more in depth view into their own production process
- ❖ Possibility/Danger for Eco-labelling and market expansion

Consumers, with those in the Scandinavian countries (Sweden in particular), have developed a keen savouring for environmentally friendly products, both for service and consumption. In many countries ecological tagging has an enormous following, and integration into this market is of paramount success. Therefore, a life cycle assessment in typical nature provides an excess of information for the public.
However, a summation of such findings should address to the public and concentrate upon:

- ❖ Environmental responsibilities of the company in question
- ❖ Particular actions/restraints taken to provide an "organic/eco" product
- ❖ How the product measures up to competition, moreover *regular wine*

The scope and other relevant information shall now be described in further detail.

2 SCOPE OF ANALYSIS

As the main objective of this LCA study is wine production, ***boundaries relating to nature*** commence with the cultivation of wine grapes (agricultural areas of vineyard) and conclude during the consumption phase as well as including land filling and recycling stages (for packaging). All studied subsystems of wine production are considered on a cradle-to-grave basis. Inputs of the survey relating to materials and energy used for agriculture, winery, packaging and transportation were accounted for. The outputs of the system include emissions from manufacturing, transport and land filling and again were evaluated. Waste packaging materials are also considered as outputs if recycling processes are not included.

2.1 GEOGRAPHICAL BOUNDARIES

As for ***geographical boundaries***, one large region was assumed, that being West Europe. Thereafter, one can distinguish two geographical sub-regions within West Europe:

- Sweden (consumer and disposal phases); Gothenburg harbour (west Sweden);
- France (viticulture and vinification phases); Bordeaux's territories with vineyards and winery plants.

However it is more accurate to use these boundaries for the manufacturing stages of wine grape cultivation and production of wine. There is a problem to define such boundaries for the consumption phase because large shares of the winery's products are exported far from the primary consumer, i.e. to Gothenburg harbour.

2.2 TIME ASPECTS

Several ***time aspects*** were considered during the study. For wine procedures the time employed was assumed from 1999 until 2003, as described in the basic overview of wine production the process can take several months to years for the activities of grape growing, winery activities and storage, also including energy consumption during winery and transportation.

2.3 CUT-OFF CRITERIA

In spite of the fact that the system boundaries are defined through the cradle-to-grave point of view, one part of given product system is not included, the relevant consumption phase. Due to the negligible environmental impact, the consumption phase of wine life cycle was eliminated from the project procedure.

2.4 ALLOCATION PROCEDURES

As the report comprises only outputs and inputs relating to the wine LCA system, this is the soul reason why it is assumed that there is no one allocation problem. However, some allocation procedures are included automatically in accordance with SimaPro calculation.

2.5 FUNCTIONAL UNIT

The final product that arrives to the customer is the wine bottle. The objective of the entire process is to produce wine for drinking. Therefore, the most obvious functional unit is employed throughout the report is one litre of wine:
Functional Unit → 1 litre of wine.

2.6 PROCESS FLOW DIAGRAM

The following figure shows the process flowchart used in the lifecycle assessment, with cut-off at system boundaries, described antecedently:

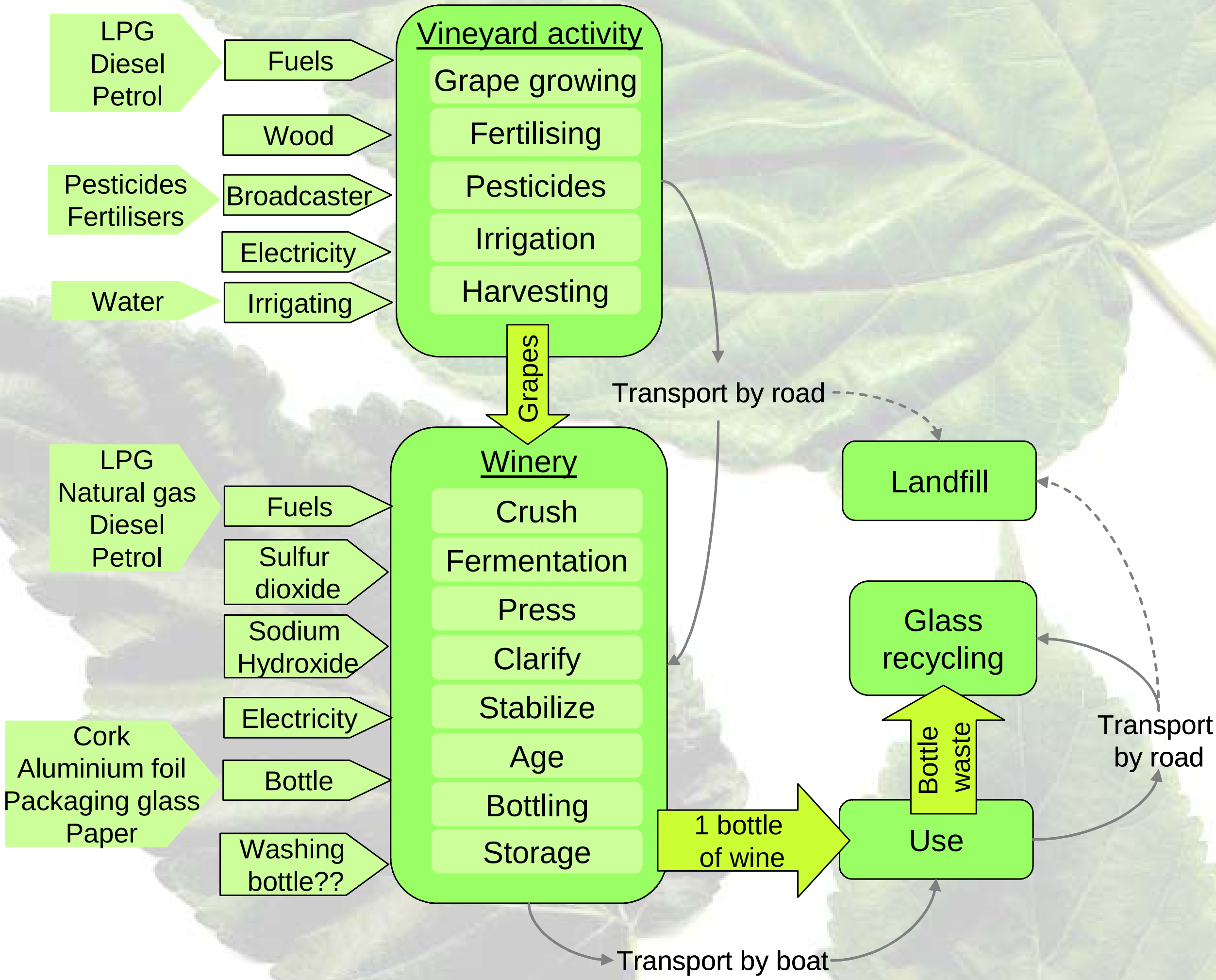

FIGURE 1: PROCESS FLOW DIAGRAM

2.7 ASSUMPTIONS AND LIMITATIONS

Decision making follows processes and calculations computed using the SimaPro Database. Therefore, most information must be included in the abovementioned database in order to more realistically model a system such as wine processing. However, extensive information on all of the emissions and materials just cannot be account for correctly due to lack of information and data on the subject. Due to the timeframe of the project, the best use of data was used to alleviate this approach and conclude the furthermost collection of data possible. In succeeding sections of the report, assumptions and limitations due to specific processes and material inputs and outputs will be specified more clearly with relevance to respective boundaries of the system.

2.8 IMPACT CATEGORIES AND IMPACT ASSESSMENT METHODS

In order to provide the information on relevant impacts to environment and etc. of wine life cycle, it is useful to utilize the Eco Indicator 99 (V 2.03), egalitarian version. This tool is sufficient for product development applications for internal use in the considered winery company. (Baumann, H.; Tillmam, A., 2004) This impact assessment method provides a clear and simple approach toward the various environmental impacts.

Identification and selection of impact categories depend generally on the goal and scope definition. Also information collected during the inventory method, amount and quality of data and limitations from SimaPro data catalogue influence greatly these procedures.

According to the ISO standard, the headlines for impact categories are distinguished as:

- resource use
- ecological consequences
- human health

These categories must be divided into sub-categories for more operational and practical applications. During the inventory impact assessment phase one can obtain the following main environmental impacts for the considered life-cycle:

- global warming
- ozone layer depletion
- acidification
- eutrophication
- photochemical oxidant formation
- depletion of fossil fuels and minerals

In addition to these categories, there are a number of environmental impacts added from Eco Indicator 99 database such as:

- carcinogens
- respiratory organics and inorganics
- land use

The model of the wine life cycle includes several sources of information for recourse and emissions datasets. Two main sources of information for inventory procedure should be distinguished:

- ❖ Automatically included resources and emissions from databases of SimaPro 6.0 (for instance pollution and resources for irrigation, land filling etc.)
- ❖ Information gathered through analyzing and calculations of environmental reports from European (Italy, France, Spain, and Sweden), American and Australian companies.

The resources and emissions used in the model create and relate to all abovementioned environmental impact categories. Here only groups of resources and emissions relevant are indicated to distinguish different process stages:

a) service data group (transport, packaging of wine and washing of bottles)
b) product data group (production of 1 litre of wine and 1 glass bottle)
c) waste data group (recycling and land filling waste scenario).

2.9 WEIGHTINGS

The core of impact inventory analysis is made from sub-phases: classification, characterization and weightings. This structure is appropriate for the given model as well. One the most important features for the weighting procedure in our case depends on use Eco Indicator 99 with ***egalitarian*** perspective, which already takes weighting into account. According to the egalitarian view, all cause-effect relations are counted as environmental impacts. All cultural considerations are taken into account. "This means that nothing is left out. In addition, a long-term perspective is applied." (Baumann, H.;Tillmam, A., 2004)

3.0 DATA

3.1 Wine Grapes (Harvesting and Growing Activities)

The processing of wine grapes can be split into various activities including the input of materials, various processes (e.g. fertilizing) and emissions to the environment. The data for these sources comes most notably from two key research papers from the Australian Wine Industry and an EPD performed for CIV & CIV, hereafter referred to as the *Australian* and *EPD* document respectively. (Australian Wine Industry, 2003), (EPD, 2006)

3.1.1 INPUTS

The following data table below outlines the extent of the inputs provided for the production of wine grapes. From the figure, the name of the input, which includes materials and processes, the amount used, followed by the SimaPro name, source of information, SimaPro database and a reference to the calculations and other relevant information in the Appendix are given. Subsequent tables for the Winery Activities, Transport and Wine bottle follow this very same model.

Grapes for Winery (Harvested Grapes)					
Input Name	Amount	SimaPro Input\Name	Reference/Source	SimaPro Database	Appendix
Irrigating	0.000222 ha	Irrigating/CH S	N/A	EcoInvent	A, B
Fertilizing	0.000222 ha	Fertilizing, by broadcaster/CH S	N/A	EcoInvent	A,B
Wood	0.0227 kg	Wood, oak European	Australia	IDEMAT 2001	B
Nitrogen Fertilizer	0.015 kg	Fertilizer-N1	WSU	IDEMAT 2001	A,B
Phosphorous Fertilizer	0.037 kg	Fertilizer-P1	WSU	IDEMAT 2001	A,B
Pesticides	0.00302 kg	Pesticides unspecified, at regional storehouse/RER S	WSU	EcoInvent	A,B
LPG	0.00010652 kg	LPG 1	Australia	IDEMAT 2001	A,B
Petrol	0.003876 kg	Petrol leaded stock Europe S	Australia	ETH-ESU 96 System Proc	A,B
Diesel	0.01252 kg	Diesel stock Europe S	Australia	ETH-ESU 96 System Proc	A,B
Electricity	0.334 MJ	Electricity France B250	Australia	BUWAL 250	B

TABLE 1: INPUTS (GRAPES FOR WINERY)

3.1.1.1 PROCESSES AND ASSUMPTIONS

Processes required in the production of wine grapes include chiefly Irrigating and Fertilizing. Values relevant for these processes were not found despite their importance in the process. Moreover, their impacts are accounted for wholly in the EPD and Australian documents which tabulate emissions, fuel consumption and electricity required for their employment. Therefore, the processes at hand and their SimaPro input hold no reference and are simply affixed to the database to create a more realistic scenario for vineyard activities. Their data does not include input of fertilizer and pesticides, so subsequent addition of this was necessary. (Australian Wine Industry, 2003)

Transportation is also required in the shipment of grapes, various vineyard chores and machinery used. However, their emissions and impacts are accounted for in the use of fuels (petrol, diesel, and LPG) and emissions of CO2, CFC’s and Methane. Therefore, no transportation mode is accounted for in the data as given.

3.1.1.2 MATERIAL INPUTS AND ASSUMPTIONS

As stated previously, impacts for transportation and growing activities at the vineyard are accounted for with the addition of fuels into the database/process for Wine Grape Harvesting. Petrol, Diesel and LPG were the primary sources attributable to the activity, and their values originated from the report by the Australian Wine Industry. (Australian Wine Industry, 2003) Values were then converted from their original state to ease input into the SimaPro database for the given functional unit. Relevant SimaPro materials were chosen from different SimaPro databases for each material, and the basic assumption of European Stock for the fuels was used. The calculations for the fuels can be seen in Appendix 1.

The wood which was input into the system is the wood needed for posts for vineyard structure (i.e. holding up the vines). Values were obtained once again from the Australian database and based on 1 hectare of vineyard. (Australian Wine Industry, 2003)

Fertilizers and Pesticides used were discovered from a document about the grape growing process in Washington, USA. (WSU, 2006) Amounts given in the document include such for 1 acre of vineyard, thereafter these numbers were converted for input into the harvesting process. Calculations given in Appendix A for Vineyard Activities. It assumed in the SimaPro databases, Appendix B, that data given refers to numbers involved in the production of the respective substances and that no further impacts have been taken into account, such as soil or water pollution due to fertilizer and pesticides use. This assumption will probably decrease the wine life cycle impact, but is considered that will not have a big influence

Electricity input for the system was tabulated from the data provided in the Australia document. (Australian Wine Industry, 2003) Numbers are given for GJ of energy per tonne of grapes produced, therefore an output in this case of kilograms allowed simplified calculations not subsequently shown in the Appendix.

3.1.2 OUTPUTS

Grapes for Winery (Harvested Grapes)					
Output Name	Amount	SimaPro Input\Name	Reference/ Source	SimaPro Database	Appendix
Carbon Dioxide	0.952 kg	Carbon Dioxide, Fossil	EPD	CAS number-000124-38-9	A,B
Chlorinated Fluorocarbons	0.0006 kg	Chlorinated Fluorocarbons, soft	EPD	N/A	A,B
Hydrogen	0.346 kg	Hydrogen	EPD	CAS number-001333-74-0	A,B
Oxygen	0.0806 kg	Oxygen	EPD	CAS number-007782-44-7	A,B
Methane	0.0018 kg	Methane	EPD	CAS number-000074-82-8	A,B
Wood Posts	0.016 kg	Wood Wastes	Australia	N/A	B

TABLE 2: OUTPUTS (GRAPES FOR WINERY)

As seen above, emissions produced during the vineyard activities include CO_2, Chlorinated Fluorocarbons, Hydrogen, Oxygen and Methane. The data in this case comes from that provided by the EPD produced for the CIV & CIV wine for polluting emissions involved in vineyard activities. (EPD, 2006) Subsequent inclusion into the database was produced using pertinent resources provided by the given SimaPro databases, as seen above. Conversions and small calculations then followed suit, and are again provided in the Appendix B (Vineyard) for further reference. Wood wastes are then produced from the vineyard posts for vine stability and health. A complex series of recycling and wastes are produced from these posts, as seen in the Australian document. However, to alleviate calculations and time, it is assumed that half of the wooden posts are disposed of to land filling operations. (Australian Wine Industry, 2003)

3.2 WINERY ACTIVITIES

3.2.1 INPUTS

Winery activities (1L Wine)					
Input name	Amount	SimaPro Input\Name	Reference/Source	SimaPro Database	Appendix
Water	2,5 l	Water, fresh	Australia	CAS number-007732-18-5	A,B
SO2	75 mg	Sulphur dioxide	Cook et al.	CAS number-007446-09-5	A,B
NaOH	1,62 g	Sodium hydroxide	Australia	CAS number-001310-73-2	A,B
Grapes	2 kg	Grapes for Winery (harvested grapes)	-	Own dataset	B
LPG fuel	0,007183 kg	LPG I	Australia	IDEMAT 2001	A,B
Natural gas	0,00474 kg	Natural gas N-sea I	Australia	IDEMAT 2002	A,B
Diesel	0,001416 kg	Diesel stock Europe S	Australia	ETH-ESU 96 System processes	A,B
Petrol	0,008436 kg	Petrol leaded stock Europe S	Australia	ETH-ESU 96 System processes	A,B
Electricity	0,551 MJ	Electricity France B250	Australia	BUWAL250	B

TABLE 3: OUTPUTS (WINERY ACTIVITIES)

The preceding table shows the inputs from the winery activities. The data for the winery stage has been collected mainly from *Australian* and *EPD* documents. Of further note, 'Grapes for Winery' refers to the datasheet created previously in SimaPro. Inputs to the system consist nearly of only grapes, different energy sources, SO_2 as additive, water and cleaning products.

3.2.1.1 LIMITATIONS AND ASSUMPTIONS FOR WINERY ACTIVITIES

The winery consists of different production stages, such as fermentation, crushing, stabilization, etc. All these operations need resources and have specific emissions. However, the data found in the Australian, EPD and Cook, G. documents refers to overall inputs and outputs of the winery, and that is how is has been resumed in the tables. (Australian Wine Industry, 2003), (EPD, 2006)
Water and NaOH are used for cleaning the equipment. SO_2 is a basic compound that has to be added to the wine. There are different energy sources in the winery, and each one has a defined use. For instance, while natural gas is used in boilers to produce hot water or generators to produce electricity, diesel is mainly used for in-site transport. (Cook et al., 1988)

3.2.2 Outputs

Winery activities (1L Wine)					
Output name	Amount	SimaPro Input\Name	Reference/Source	SimaPro Database	Appendix
Carbon dioxide	1,665 kg	Carbon dioxide, fossil	EPD	CAS number-000124-38-9	A, B
CFC	0,0059 kg	Chlorinated fluorocarbons, soft	EPD	N/A	A,B
Hydrogen	0,000429 kg	Hydrogen	EPD	CAS number-001333-74-0	A,B
Oxygen	0,257 kg	Oxygen	EPD	CAS number-007782-44-7	A,B
Methane	0,0016 kg	Methane	EPD	CAS number-000074-82-8	A,B
Packaging waste	0,0116 kg	Packaging waste, paper and board	Australia	N/A	B
Waste	0,0566 kg	Waste, unspecified	Australia	N/A	B

Table 4: Outputs (Winery Activities)

When it comes to outputs, the air pollutants are the same as in vineyard activities, and are taken from the same information source, EPD. Apart from that, some solid waste is also generated, mainly packaging waste such as paper and cardboards, and various solid waste containing old filters or cellar doors. Further data assumptions are collected in Appendix B, while calculations are written in Appendix A.

3.3 Bottling Phase

3.3.1 Inputs

Wine Bottle (0.75 L)					
Input Name	Amount	SimaPro Input\Name	Reference/Source	SimaPro Database	Appendix
Cork	0,01173 kg	Raw cork, at forest road/RERS	EPD	Ecoinvent	B
Aluminium	0,00175 kg	Aluminium foil B250	EPD	BUWAL 250	B
Paper	0,0032 kg	Paper woody C B250	EPD	BUWAL 250	B
Glass	0,853 kg	Packaging glass, green at plant/CH S	EPD	Ecoinvent	B
Washing Glass	1 point	Washing bottles (1l)	SimaPro catalogue	BUWAL 250	B

Table 5: Wine Bottle Inputs

The bottling process includes several processes: bottling-corking-labelling- washing of bottles. Information concerning bottle production is provided both from specific data and inputs used from the given SimaPro database. Specific data is obtained using information from the EPD and Australian documents. Applicable numbers include input aspects as: cork, aluminium, paper and glass consumption for the bottle production.

Subsequent to this information, the process of washing bottles before filling and transportation is considered with needed indexes from SimaPro databases BUWAL 250 and ECOINVENT databank. The LCA includes the consumption of natural and energy resources, the emissions into the environment and the production of waste.

3.3.1.1 ASSUMPTIONS AND LIMITATIONS FOR BOTTLING

In the bottling process there are some limitations and assumptions to be made about all of the materials needed for the bottling process. Subsidiary products (e.g. glue, ink, etc.) are not included due to absence of information available and the incredibly small amount of employment of the products respectively. Water resources are also automatically included in the washing bottles stage (see Appendix B, Bottling).
Fuels and electricity used to produce input materials are automatically taken into account of SimaPro Database catalogue (see Appendix B, Bottling).
Amount of fuel and electricity used for filling of bottles is not calculated due to avoid the overlapping. Of further note, overall electricity consumption for Winery Activities includes bottling in its calculations; therefore it is not necessary to double the amount of electricity.

3.3.2 OUTPUTS

Quantity and diversity of outputs are not well defined due to lack of gathered information. There are no outputs from specific databases. Only a small number of separate outputs from SimaPro data catalogue are available for the report making. (See Appendix B)

3.4 TRANSPORTATION PHASE

Transport operations described are associated with transport between the winery facilities and consumption phases. This stage covers loading ready bottled wine in La Rochelle, France harbour and transporting it to Gothenburg, Sweden harbour in a vessel by sea. Other transport activities which occur from the winery facility to the harbour and from Gothenburg harbour to secondary consumers are not included. The former is assumed to have relatively small environmental effect and therefore is cut off. And the later transport to secondary consumer was not taken into account because of difficult variability of local (Swedish) consumer network.

3.4.1 INPUTS

For the modelling of the transport phase only one process stage from SimaPro is used, to show the shipment process from La Rochelle to Gothenburg. For this transport by boat, the index “tonne-kilometres” is applied. The given index is considered as a multiplication of the distance with the amount (weight) of goods transported. In the present case the calculations are shown for the transportation of one bottle of wine in Appendix A, Transport for further understanding.(Volvo Ocean Race, 2001)

3.4.2 OUTPUTS

There is a wide range of outputs possible from SimaPro Database, such as emissions to air, water waste (see Appendix B, Transportation). All emissions are automatically included in the program and therefore they do not require more specific calculations or assumptions.

3.5 WASTE ACTIVITIES

Waste activities take place in the final part of the studied life cycle. They comprise a certain number of waste landfill and recycling operations and transportation of used wine bottles from consumer to a disposal phase. It is assumed that waste handling has only mono outputs locating within the system boundaries. Therefore allocation procedures are not required for correct calculations.

3.5.1 INPUTS

Waste Disposal Activities					
Input Name	Amount	SimaPro Input\Name	Reference/Source	SimaPro Database	Appendix
Transportation	0.01706 tkm	Truck 16t B250		BUWAL 250	A,B
Collected glass	0.853 kg	Wine bottle recycling	EPD		B
Recycling glass	86% of collected	Recycling glass B250	Swedish Institute	BUWAL 250	B
Landfilling	14% of collected	Landfill B250 (98)	Swedish Institute	BUWAL 250	B

TABLE 6: INPUTS AND OUTPUTS OF WASTE DISPOSAL ACTIVITIES

For the calculations and forming the model, the following information about inputs is needed:

- fuel
- energy
- amount of recycled and landfiled bottles
- distance from consumer to waste handling facilities
- weight of a wine bottle

3.5.1.1 ASSUMPTIONS AND LIMITATIONS

Amount of energy and fuels needed for transport and recycling and land filling operations are defined automatically with SimaPro catalogue accordance. It is convenient to do the same calculations for 'tonne-kilometers' index of waste as previously for transportation of wine bottles. For further specifications see Appendix A, Transport. The distance provided is 20 kilometers which includes average urban and suburban distance from consumer to waste facilities.

3.5.2 OUTPUTS/EMISSIONS

There is no need to define specific outputs and additional calculations for them because in the given case all required outputs are accounted for from the research in the SimaPro catalogue. The list of emissions can be founded in Appendix B, Transport.

4.0 RESULTS

Upon completion of the LCA analysis with SimaPro, significant positive and negative effects of the stages in the Life Cycle for wine production have been identified and subsequently shown. In the first analysis, the weighted assessment of impact categories is identified with normalization and weighting parameters applied according to the Eco-Indicator 99 egalitarian method. Figure 2 below, shows the environmental impact categories that have been defined before in precedent reading. Its data also shows the positive effect of the glass bottle recycling stage, which is shown shaded in with green.

According to Figure 2, the fossil fuels impact category has the most significant impact, with up to 52 mPt (including the positive effect of recycling). Moreover, the respiratory inorganics category impact has a great influence (30mPt) on human health, ecological consequences and resources as well. This is followed by the climate change category again having significant impacts (12mPt).

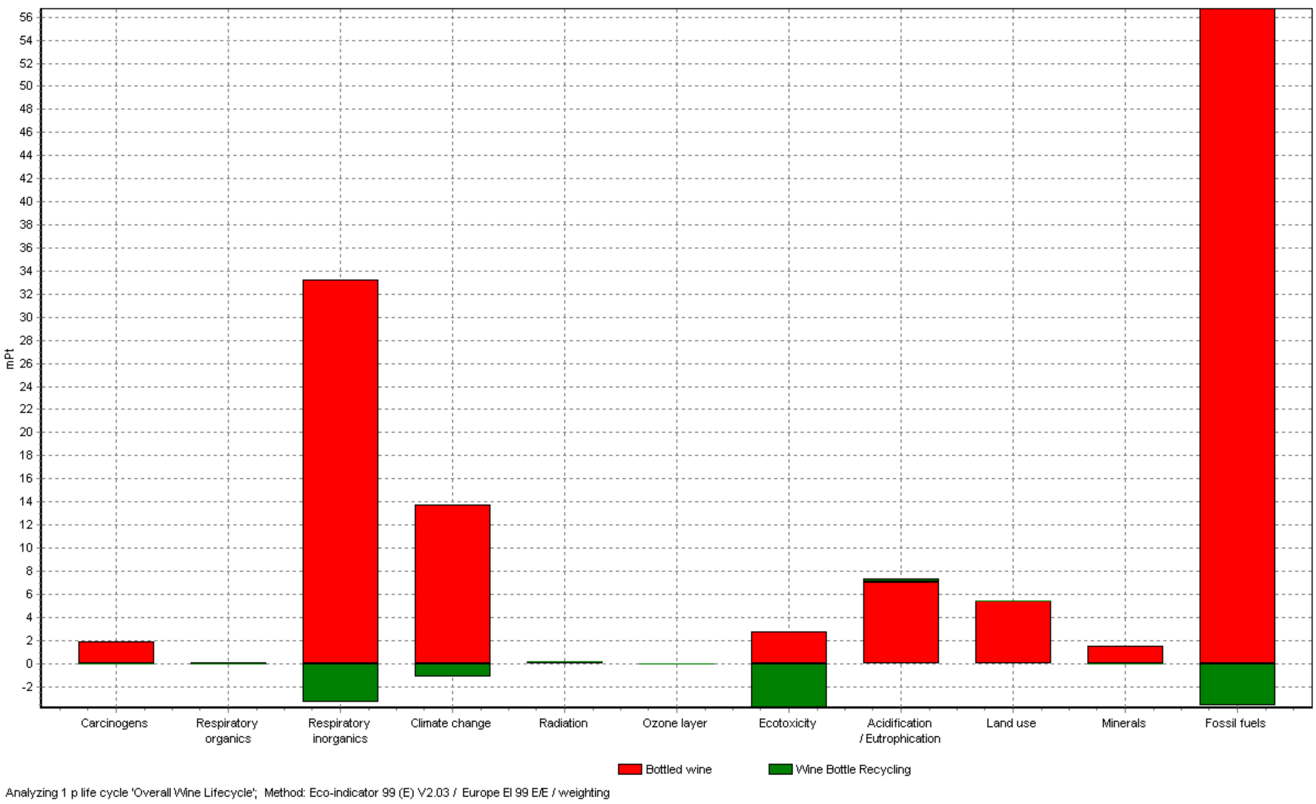

FIGURE 2: WEIGHTING OF IMPACT CATEGORIES FOR WINE LIFE CYCLE

Hereafter, single score analysis was produced to find the significance of impacts, and moreover their similarities. Based on the results of the flow diagram, Figure 1 of Appendix C shows the three main stages, which have relatively similar scale of impacts. These main stages can be classified as the Wine (1L), Wine Bottle and Transport stage. Their overall impacts vary from 32.5 % (wine bottle stage) to 40.9 % (transport). Moreover, the relevant effect of the recycling process should be taken into account, which accounts for -11%. Refer to Figure 1 in Appendix C for further review of the preceding discussion.
Given that fossil fuels account for the largest impact in the life cycle for the wine production, the relative magnitude of the processes impact on fossil fuel consumption was subsequently measured. Figure 2 of Appendix C illustrates the wine production

flow chart for fossil fuels. The figure should help to find where fossil fuels have high impact source. The main causes are:

- Production of crude oil used in transport stage.
- Packaging glass production stage.
- Vineyard activities, especially irrigation and diesel use and pesticide production.

Thereafter, Figure 3 of Appendix C illustrates the wine flow chart for inorganic respiratory impact category, the second important impact found. The main causes associated with this impact are:

- Up to 67.3% is contributed by the burning of fuels in the transport stage.
- Packaging glass production.
- Irrigation process in vineyards.

A single score analysis for each main life cycle stage, Wine production, wine bottle production and transport was then produced and results can be seen in Figure 4 of Appendix C. In other words, this single score assessment produces the overall impact of each aspect. Chiefly, transport by container ship is the most harmful, probably due to the large transport distances from France to Sweden. Transport is then followed by wine production and glass production. It is worth noting that the fossil fuels impact category remains similar in all the stages, while respiratory inorganics and climate change categories make the difference in transport and wine production respectively.

Of further accord, it can be noted that the greatest impact to climate change is produced in the wine production itself. At the top of the hierarchy, the output of one litre of wine produces an impact holding 81.5% of the impacts associated to climate aspects. Once again, as well, the wine bottle assembly and container ship process then affix relatively significant impacts. These results can be seen in Figure 5 of Appendix C for additional support.

According to ISO, weighting should not be used if the goals of an LCA are to compare two alternative products. (Bauman et al., 2004) However, in this case there is no comparison of LCA objectives and therefore weighting was used to determine which parameters create the greatest environmental and human health consequences. As mentioned previously, the egalitarian version of EcoIndicator 99 provides weightings of its own accord, giving maximum precedence to the cultural and environmental effects.

4.1. ECO-WINE INVESTIGATION RESULTS

After investigating the results for impacts produced with regular wine production, the assessment of the similarities and differences of a theoretical eco-wine production was then conducted. First of all, Figure 1 in Appendix D shows the life cycle of the normal wine production stage. According to Figure 1 in Appendix D, irrigation is the worst process in the wine production, with 29,2% rated by the single score of the overall wine production process. It is followed by Pesticides production with 9.92%.

One of the typical differences between wine and eco-wine is that the later does not use pesticides and fertilizers in the vineyard activities. In this case, both substances sum to 23.83% of the overall impact. It is assumed that all changes in the eco-wine production will refer again only to vineyard activities.

Hereafter, in order to be able to create an equivalent model for eco-wine, it is assumed that eco-wine fertilizers are replaced with the same amount of compost, while pesticides are totally removed. Biodiversity and pest management by natural bug predators would be developed instead. Results of these changes can be checked in Figure 2 in Appendix D.

The compost use effect then totals to only 2.92% with the analysis of single scoring of the total eco-wine production stage, which means a reduction of nearly 20%.

On the other hand, this investigation focuses primarily on the impact in only the production of eco-wine and tests should be subsequently run on the overall wine life cycle. According to Figure 3 in Appendix D and Figure 2 of Appendix C, the output of 1L of wine based on single scoring analysis sums up to only 32.5% of the overall impact, compared to 37,2% from producing common wine.

Apart from this, impact categories for eco-wine life cycle are weighted in Figure 4 of Appendix D. If impact categories between Wine and Eco-wine are compared (see Figure 5 of Appendix D), a slight decrease in all impact categories, but Acidification/Eutrophication are obtained with Eco-wine, showing that eco-wine lessens the impacts during the wine production process. But, then the question can be raised of whether or not these impacts are significantly reduced to classify a wine with reduced fertilizers and an exclusion of pesticides as substantially ‘organic.’

CONCLUSIONS

In regards to the aims set out at the beginning of the study, the following results were obtained from the research the crucial activities, and thus the most significant impacts were identified.

The conclusions that are drawn from the results are outlined as follows:

- Fossil fuel impact category has, by far, the most significant impact.
- Recycling produces a positive effect.
- The three stages (wine production, glass production and transport) have similar overall impacts.
- Transportation creates the largest impact between the three stages. However, impacts from transportation are relative to distances. In this case, wine bottles are transported from France to Sweden, but this does not always hold true in every case but only for the given specifications. Therefore, transport should not be our main goal when trying to decrease the wine's life cycle impacts.
- On the other hand, packaging glass production has a significant impact. Nevertheless, most of the wine bottles are recycled at their end of life which alleviates this problem by balancing the impacts.
- In conclusion, efforts should focus on environmental impacts associated with the wine production (grape harvesting and winery activities).

Wine vs. Eco-Wine production analysis:

- In the previous chapter differences between normal wine and eco-wine have been analysed. The results confirm that eco-wine is slightly better than normal wine. However, the assumptions made may not be accurate. It is most likely that higher amounts of compost have to be used in order to achieve the same fertilizing efficiency. Besides, some other kind of inputs apart from natural pest predators could be needed to control pests.
- Ecological wine, although not proven to hold the greatest decrease in impacts to the environment, holds high regard in its attempt to alleviate the impacts. The process seems to be more of a 'labour of love' by the vineyard and winery owners, and therefore embraces a special classification for the exclusive wine connoisseur.

In spite of a wide range of results obtained from the project, there still remain a few unanswered questions. These questions are as follows based on the study:

Is it possible to classify one specific activity which definitely reduces all environmental impacts, or is there only an allocation of the problem?

Would it be necessary to further define the extent of the positive and negative effects associated with changing inputs/outputs of any process in the wine production? That is, how do different values effect the overall life cycle assessment?

It is rather surprising to distinguish that the processes associated with the winery and vineyard activities influence the climate change at a higher level than the transport phase, associated with consuming much more fossil fuels. See Figure 5 of Appendix C for further specifications.

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Appendices

Appendix A- *Specific Calculations for Activities*

Appendix B - *Name and Description of Inputs/Outputs from the SimaPro Catalogue*

Appendix C- *Regular Wine Figures from SimaPro*

Appendix D- *Eco-Wine Figures from SimaPro*

Appendix E- *Process Data Sheet*

APPENDIX A: SPECIFIC CALCULATIONS FOR ACTIVITIES

1. VINEYARD ACTIVITIES (WINE GRAPE HARVESTING)

Transport + Stationary Fuels Consumption Calculations

The data given was for liters of fuel used per tonne of grapes produced. Thereafter, the amount of energy per liter was used, followed by the conversion with the energy density to find the amount of each fuel necessary (in kilograms) per kg of grapes used. (Australian, 2003), (EPD, 2006)

LPG

$$0.2L/1000kg \times 24.5MJ/L \times kg_{fuel}/46MJ = \frac{0,000010652kg_{fuel}}{kg_{grape}}$$

Diesel

$$14.2L/1000kg \times 37.9MJ/L \times kg_{fuel}/43MJ = \frac{0.01252kg_{fuel}}{kg_{grapes}}$$

Petrol

$$5.1L/1000kg \times 34.2MJ/L \times kg_{fuel}/45MJ = \frac{0.003876kg_{fuel}}{kg_{grapes}}$$

Emissions Calculations

For the calculations below, the data given is for kilograms or moles of the emission type per liter of wine. Therefore, the data must be converted, since for every liter of wine 2 kg of grapes are needed. (Australian, 2003), (EPD, 2006)

CO_2

$$0.491\,kg/L \times L/2kg_{grapes} = \frac{0.2455\ kg}{}$$

CFC-11

$$0.0003kg/L \times L/2kg_{grapes} = \frac{0.00015kg}{kg_{grapes}}$$

H (Hydrogen)

$$0.1730mol/L \times 1L/2kg_{grapes} \times 1g/1mol = \frac{0.0865g}{kg_{grapes}}$$

O_2 (Oxygen)

$$0.0403kg/L \times L/2kg_{grapes} = \frac{0.02015kg}{kg_{grapes}}$$

C_2H_4 (Methane)

$$0.0009kg/L \times L/2kg_{grapes} = \frac{0.00045kg}{kg_{grapes}}$$

Unit Conversions for Area:

3,000 to 6,000 kg grape per hectare → 4500 kg grape per hectare, or 1800 kg pre acre.

The final unit should refer to kg of grape.

Fertilizers

Advisable addition of nitrogen is from 30 to 100 lb per acre. Middle value has been chosen: 60 lb N/acre. (WSU, 2006)

$$\frac{60\,\frac{lb\_N}{acre}}{1800\,\frac{kg\_grape}{acre}} = 0{,}0333\,\frac{lb\_N}{kg\_grape} \longrightarrow 0{,}0333\,\frac{lb\_N}{kg\_grape} \cdot 0{,}453\,\frac{kg}{lb} = 0{,}015\,\frac{kg\_N}{kg\_grape}$$

For potassium addition, 150 lb K/acre has been chosen:

$$\frac{150\,\frac{lb\_K}{acre}}{1800\,\frac{kg\_grape}{acre}} = 0{,}0833\,\frac{lb\_K}{kg\_grape} \longrightarrow 0{,}0833\,\frac{lb\_K}{kg\_grape} \cdot 0{,}453\,\frac{kg}{lb} = 0{,}037\,\frac{kg\_K}{kg\_grape}$$

Pesticides

12 lb_pesticides/acre, including fall or early winter application, spring application and temporary control. It has been assumed that 4 lb_pesticides/acre has been applied each time (data has been based in napropamide (Devrinol 50DF)) (WSU, 2006)

$$\frac{12\,\frac{lb\_Pest.}{acre}}{1800\,\frac{kg\_grape}{acre}} = 0{,}0066\,\frac{lb\_Pest}{kg\_grape} \longrightarrow 0{,}0066\,\frac{lb\_Pest}{kg\_grape} \cdot 0{,}453\,\frac{kg}{lb} = 0{,}00302\,\frac{kg\_Pest}{kg\_grape}$$

2. Winery Activites

Transport + Stationary Fuels Consumption Calculations

The data given was for liters of fuel used per tonne of grapes produced. Thereafter, the amount of energy per liter was used, followed by the conversion with the energy density to find the amount of each fuel necessary (in kilograms) per kg of grapes used. (Australian, 2003), (EPD, 2006)

LPG

Transport

$$11.9L/1000kg \times 24.5MJ/L \times kg_{fuel}/46MJ = \frac{0{,}006338kg_{fuel}}{kg_{grape}}$$

Stationary

$$14.9\% \times 0.261MJ_{total} \times kg_{fuel}/46MJ = \frac{0{,}000845kg_{fuel}}{kg_{grapes}}$$

$$Total = \frac{0{,}007183kg_{fuel}}{kg_{grapes}}$$

Diesel

Transport

$$1{,}3L/1000kg \times 37.9MJ/L \times kg_{fuel}/43MJ = \frac{0{,}0011kg_{fuel}}{kg_{grape}}$$

Stationary

$$5.22\% \times 0.261MJ_{total} \times kg_{fuel}/43MJ = \frac{0{,}000316kg_{fuel}}{kg_{grapes}}$$

$$Total = \frac{0{,}001416kg_{fuel}}{kg_{grapes}}$$

Petrol

Transport

$$5.1L/1000kg \times 34.2MJ/L \times kg_{fuel}/45MJ = \frac{0.003876kg_{fuel}}{kg_{grapes}}$$

Stationary

Very minor amount, therefore assumed to be zero

Natural Gas

Transport

No data available

Stationary

$$79.9\% \times 0.261 MJ_{total} \times kg_{fuel}/46MJ = \frac{0,00474 kg_{fuel}}{kg_{grapes}}$$

Emissions Calculations

For the calculations below, the data given is for kilograms or moles of the emission type per liter of wine. No conversion to kg of emissions to kg of grapes used is needed, since the output is labelled per liters of wine. There are three inputs added together, the first of which is for the crushing of grapes, the second for vinification and bottling and ending with emissions from transport. Again all of these stages are considered to be part of the winery activities. (Australian, 2003), (EPD, 2006)

CO_2

$$0.156kg/L + 0.742kg/L + 0.767kg/L = \frac{1.665kg}{L}$$

CFC-11

$$0.0005kg/L + 0.0051kg/L + 0.0003kg/L = \frac{0.0059kg}{L}$$

H (Hydrogen)

$$0.0120kg/L + 0.1490kg/L + 0.2680kg/L = \frac{0.000429kg}{L}$$

O_2 (Oxygen)

$$0.0016kg/L + 0.0271kg/L + 0.0699kg/L = \frac{0.257kg}{L}$$

C_2H_4 (Methane)

$$0.0kg/L + 0.0007kg/L + 0.0009kg/L = \frac{0.0016kg}{L}$$

Input Calculations

SO_2

75ppm or equivalent 75 mg of SO_2 per litre of wine is added to the wine. It doesn't need unit change.

3. TRANSPORT

1,990 km[1] *x* ***0.001853 tonnes***[2] *= 3.68747 Tonne-Kilometers Required*

[1] - distance from La Rochelle to Gothenburg
[2] – weight of transported bottled wine
(Volvo, 2001)

4. WASTE SCENARIO

Transportation of Wastes Calculation

20 ***km***[1] *x* ***0.000853 tonnes***[2] *= 0.01706 Tonne-Kilometers Required*

[1] - distance from consumer to waste handling plant
[2] - weight of one bottle transported (Swedish Institute, 2005)

APPENDIX B: NAME AND DESCRIPTION OF INPUTS/OUTPUTS FROM THE SIMAPRO CATALOGUE

1. VINEYARD ACTIVITIES

Fertilizing by broadcaster/CH S:
Translated name: Düngen, mit Schleuderstreuer
Included processes: The inventory takes into account the diesel fuel consumption and the amount of agricultural machinery and of the shed, which has to be attributed to the fertilising. Also taken into consideration is the amount of emissions to the air from combustion and the emission to the soil from tyre abrasion during the work process. The following activities where considered part of the work process: preliminary work at the farm, like attaching the adequate machine to the tractor; transfer to field (with an assumed distance of 1 km); field work (for a parcel of land of 1 ha surface); transfer to farm and concluding work, like uncoupling the machine. The overlapping during the field work is considered. The amount of spread fertiliser is not taken into account. Not included are dust other than from combustion and noise.
Remark: Fertiliser broadcaster, 500l carrying capacity, fertiliser not included. FU is one ha fertilised.; Geography: The inventories are based on measurements made by the FAT, in Switzerland.
Technology: Emissions and fuel consumption by the newest models of tractors set into operation during the period from 1999 to 2001.
Time period: Measurements were made in the last few years (1999-2001).
Version: 1.2
Energy values: Undefined

Irrigation/CH S:
Translated name: Bewässern
Included processes: The inventory takes into account electricity and diesel fuel consumption, the amount of agricultural machinery, of the shed and the further infrastructure like pump or water hose, etc., which has to be attributed to the irrigation. Also taken into consideration is the amount of emissions to the air from combustion and the emission to the soil from tyre abrasion during the work process. The following activities where considered part of the work process: preliminary work at the farm, like attaching the adequate machine to the tractor; transfer to field (with an assumed distance of 1 km); field work (for a parcel of land of 1 ha surface); transfer to farm and concluding work, like uncoupling the machine. The overlapping during the field work is considered. The amount of water irrigated is taken into account. Not included are dust other than from combustion and noise.
Remark: Overhead watering of one ha during one year (4 times 300 m3 water). Mobile sprinkler system, with fix installed pump (30 m3/h, 7-8 bar, 22 kW), water pipe and hydrant, turbine propulsion, 300 m water hose, exterior diameter 75 mm. Water amount of 1200 m3 per ha and year included.; Geography: The inventories are based on expert estimation made by the FAT, in Switzerland and literature values from Germany and Austria.
Technology: Emissions and fuel consumption by the newest models of tractors set into operation during the period from 1999 to 2001.
Time period: Measurements were made in the last few years (1999-2001).
Version: 1.2
Synonyms: Beregnen

Energy values: Undefined

LPG I

Liquified gas. By-product of refinery process. Equal assumed to the production of general refinery products. LHV 24.4MJ/l=45.5MJ/kg.

Petrol leaded stock Europe S

Petrol leaded from stock Europe ETH (ton out), original German title: Benzin verbleit ab Regionallager Euro.
Total aggregated system inventory. This is a single results record of the similar unit process. Small differences can occur due to rounding.

Regional distribution (stock)
Regional distribution includes storage in large stocks and the supply to the customer (households, companies and filling stations). The requirements and emissions during regional distribution are modeled on a product-specific basis. Vapor emission control is modeled according to the Swiss situation where 27% of the stocks and refineries and 77% of filling stations are equipped with emission control (status on January 1st 1993). Besides the infrastructure and the energy consumption for the movement of goods, production waste (sludges from oil sumps and oil tanks), and hydrocarbon emissions (specified) are included on a product-specific basis. Additionally land use, and waterborne pollutants are recorded.

Diesel stock Europe S

Diesel from stock Europe ETH (Lower Heating Value=42.8 MJ/kg) , original German title: Diesel ab Regionallager Euro.Total aggregated system inventory. This is a single results record of the similar unit process. Small differences can occur due to rounding.

Regional distribution (stock)
Regional distribution includes storage in large stocks and the supply to the customer (households, com-panies and filling stations). The requirements and emissions during regional distribution are modeled on a product-specific basis. Vapor emission control is modeled according to the Swiss situation where 27% of the stocks and refineries and 77% of filling stations are equipped with emission control (status on January 1st 1993). Besides the infrastructure and the energy consumption for the movement of goods, production waste (sludges from oil sumps and oil tanks), and hydrocarbon emissions (specified) are included on a product-specific basis. Additionally land use, and waterborne pollutants are recorded.

Electricity France B250

Model for the production of electricity in France, including production and transport of primary energy sources, excluding the infrastructure of the energysystems.
Medium Voltage, average efficiency 30.4% including 1,8% grid losses. 0.1% electricity from non-defined sources.

Pesticides, unspecified, at regional storehouse/RER S

Translated name: Pestizid unspezifiziert, ab Regionallager
Included processes: Fuel and energy consumption for the production process of the pesticide. Infrastructure requirements and transports to the regional storage are included. Waste generation is also considered.
Remark: Values represent the average of the inventories of all active ingredients (totally 41) included in Green (1987). ; Geography: The values given in the reference

used for this inventory primarily apply to US American conditions. It is assumed that these figures can be applied to the manufacturing process in the European Union.
Technology: Values given in the reference represent approximated values which are based on hypothetical material flow sheets and line diagrams from which the energy input of manufacturing process was derived. The manufacturing process was modelled on information given about the method of manufacture in the patents or, in case of pesticides which are no longer subject to patent protection, on detailed literature on the production process.
Time period: Year when reference used for this inventory was published.
Version: 1.2
Energy values: Undefined
Production volume: No data available. Sales of agr. Pest. in EU were 300000 t active ingr in 1996.

Fertilizer-N I
LCA for production of N-fertilizer in the Netherlands. Data of 8 producers in the Netherlands, averaged over 1993.

Potassium chloride, as K_2O, at regional storehouse/RER S
Translated name: Kaliumchlorid, als K2O, ab Regionallager
Included processes: Starting from mining of potash salts, the processes of concentration of the potassium chloride, conditioning, drying and transport to the regional storage were included. The use of the resource sylvinite was accounted for as well as the disposal of the salt residues on heaps and to rivers. Treatment of other wastes was included. Coating and packaging of the final fertiliser products were not included. Infrastructure was included by means of a proxy module.
Remark: Refers to 1 kg K2O, resp. 1.67 kg potassium chloride with a K2O-content of 60.0%
CAS number: 007447-40-7; Formula: KCl; Geography: The data refer to Germany.
Technology: The potash salts stem from underground mines. Three different technologies are used to concentrate the salt: solution in hot water, flotation and electrostatic separation. The inventory describes a mixture of these processes.
Time period: Data come from an environmental report for the year 2000.
Version: 1.2
Energy values: Undefined
Percent representativeness: 27.0
Production volume: 3.1 mio t in Germany, 11.6 mio t in Europe in 2000

2. WINERY

Natural gas N-sea I
Includes refinery and transportation to the shore. HHV=54MJ/kg, LHV = 38.8 MJ/kg.

LPG I
As defined above in the Vineyard Activities

Petrol leaded stock Europe S
As defined above in the Vineyard Activities

Diesel stock Europe S
As defined above in the Vineyard Activities

Electricity France B250
As defined above in the Vineyard Activities

3. BOTTLE ASSEMBLY

Raw cork, at forest road/RER S
Translated name: Kork, roh, ab Waldstrasse
Included processes: Includes manual harvesting of the cork (every 10 years) and motor-manual processes for thinning and final cutting of the trees. Also included are the transport of the workers to the forests for harvesting cork and the transport of the products to the nearest forest road.
Remark: the volume of wood produced refers to the wood not including the bark. The multi-output process "cork, harvesting / thinning / final cutting, under bark delivers the two coproducts "wood, cork oak, under bark, u=70%, at forest road" and "raw cork, at forest road". The allocation is based on the over-all revenue of wood and cork production.; Geography: data for Germany (forestry processes) and Portugal used for Europe
Technology: The harvesting of wood considers the motor-manual processes for "Buche, II. Ertragsklasse, starke Durchforstung"
Time period: cork yield data from 1993
Version: 1.2
Energy values: Undefined
Production volume: unknown

Aluminium foil B250
Production of aluminium foil from hot-rolling, cold-rolling and annealing aluminium ingots to foil with a thickness of 7-12 micron. Data derived from EAA (1993). Imports of ingots are based on the Swiss situation, this means 40% Canadian and 60% Western European production.

Paper woody C B250
Production of wood containing coated paper (94% dry matter) mainly from mechanical wood pulp with some bleached sulphate cellulose and latex coating in 1 factory in Switzerland (1993/1994). This paper is mainly used in the printing industry.

Packaging glass green, at plant/CH S
Translated name: Verpackungsglas, grün, ab Werk
Included processes: This module includes the material and energy efforts for: preparation and sorting of cullets, melting, forming of glass containers, cooling down, packaging and palletting until glass containers are ready for transport to customer. Transports for the input materials are included as well as direct emissions to air, waste water and waste.; Geography: production mix for Switzerland, based on mix of Vetropack group
Technology: Technology used by Vetropack in its different glass production sites
Time period: represents the mix of Vetropack on Swiss market for 2002 and the following years
Version: 1.2
Energy values: Undefined
Percent representativeness: 100.0
Production volume: Total production of Vetropack 2000: 762 kt
Washing bottles (1l)
Cleaning bottles (1000 p, 1 ltr, PET or Glass) Data are derived from one factory in Switzerland and only include the cleaning process. Inventories of most auxiliaries have not been carried out. Production of the bottles is NOT included. Waste treatment is not included.

4. TRANSPORT

Container ship I
Typical example: Container ship (summer)DWT 33400t/ GRT 30500t/ NRT 3700t. Fuel consumption 70t HFO at 19 knots and 3t DFO per day. Capable of transport of 2225 TEU's (empty 2t each) and 660FEU's (4t), hence a net load of 6610t!
No harbour operations i

Truck 16t B250
Road transport by diesel-truck (16t); per tonne.km; average load 50%.
Source ESU-ETHZ (1994). Production of fuels is included.

5. DISPOSAL

Recycling glass B250
Data for the recycling of glass. Inputs/outputs are taken from the material proces glass (green) B250, which is 99 % recyclied glass. Avoided product is glass (virgin), which is calculated by substracting the recycling part (approximated by glass (green) from glass (white) B250, which is 45% virgin and 55% recycled glass . This waste treatment process is not part of the original BUWAL250 study and is not reviewed by EMPA.

Landfill B250 (98)
This record is intended to be used with BUWAL data. More detailed data for plastics (PET, PE, PP, PS, PVC, PVDC) other plastics treated as PE. BUWAL does not take "avoided emissions" into account. This record is not peer reviewed by EMPA.
Partially updated December 1998

Disposal, building, waste wood, untreated, to final disposal/CH S
Translated name: Entsorgung, Gebäude, Altholz unbehandelt, in Beseitigung
Included processes: transport to dismantling facilities, final disposal of waste material,

Remark: The waste contains 1kg untreated wood (GSD=100%) Waste density is 720 kg/m3. Allocation of energy production in waste incineration: no substitution or expansion. Total burden allocated to waste disposal function of waste incinerator.;
Geography: Specific to the technology mix encountered in Switzerland in late 1990ies
Technology: Building demolition with skid-steer loaders.
Version: 1.2
Energy values: Undefined

APPENDIX C: REGULAR WINE FIGURES FROM SIMAPRO

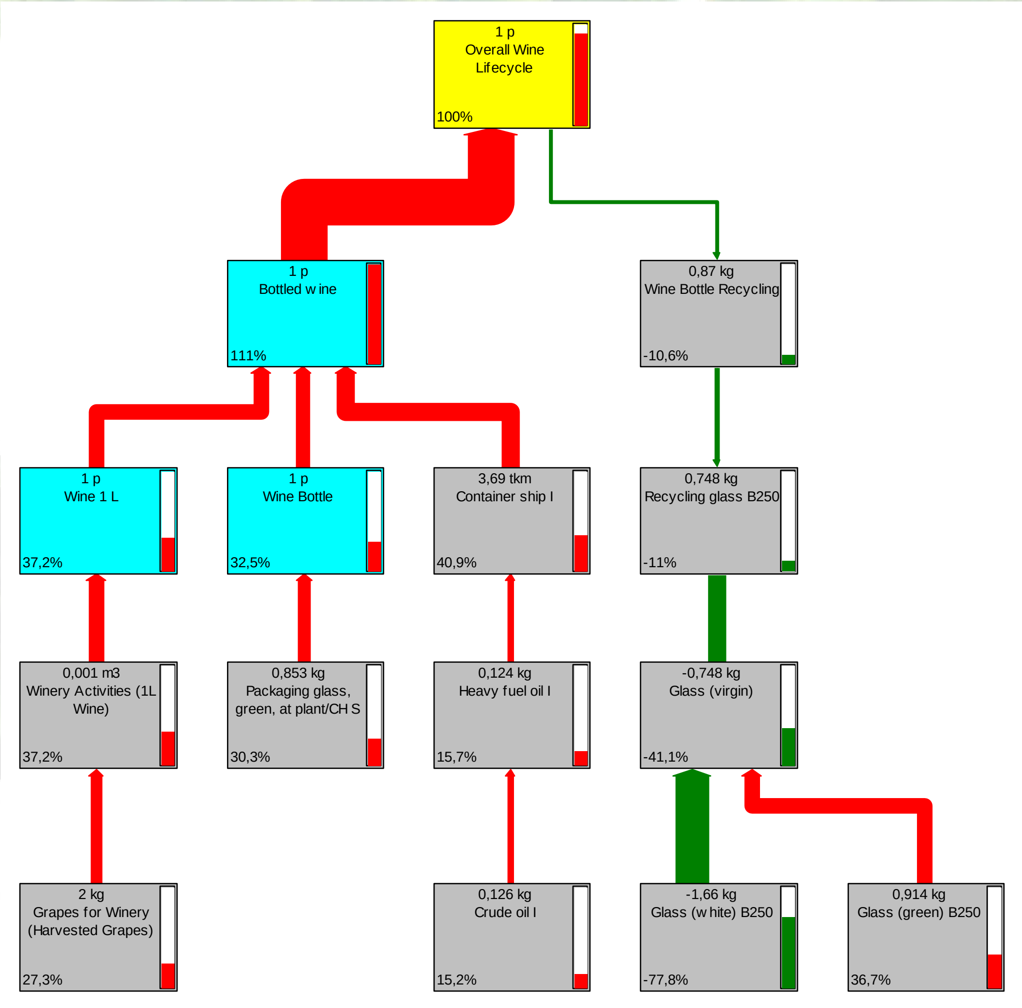


FIGURE 1: SINGLE SCORE BASED WINE FLOW-CHART

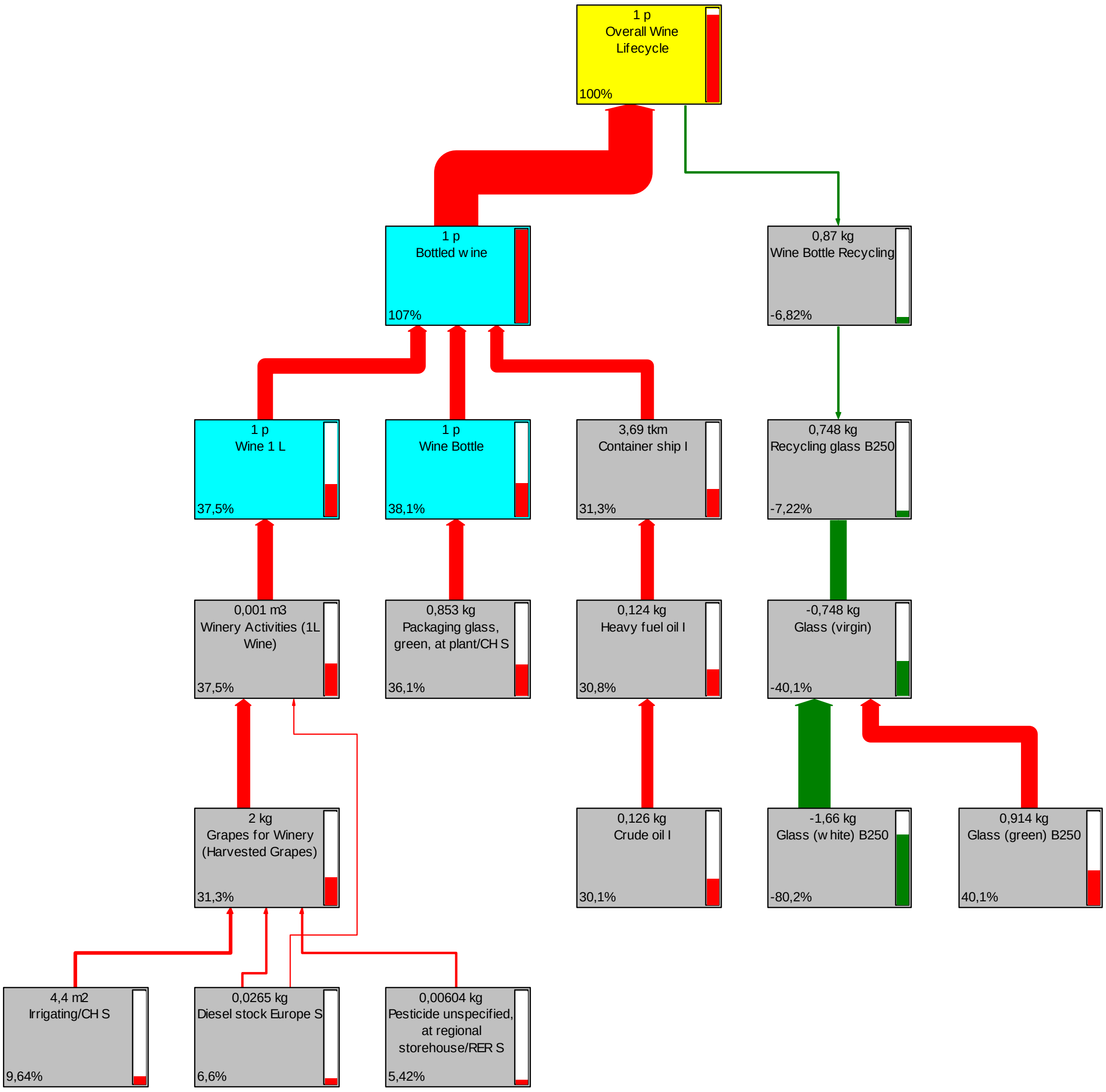


FIGURE 2: CHARACTERIZATION OF THE WINE FLOW CHART ACCORDING TO FOSSIL FUELS

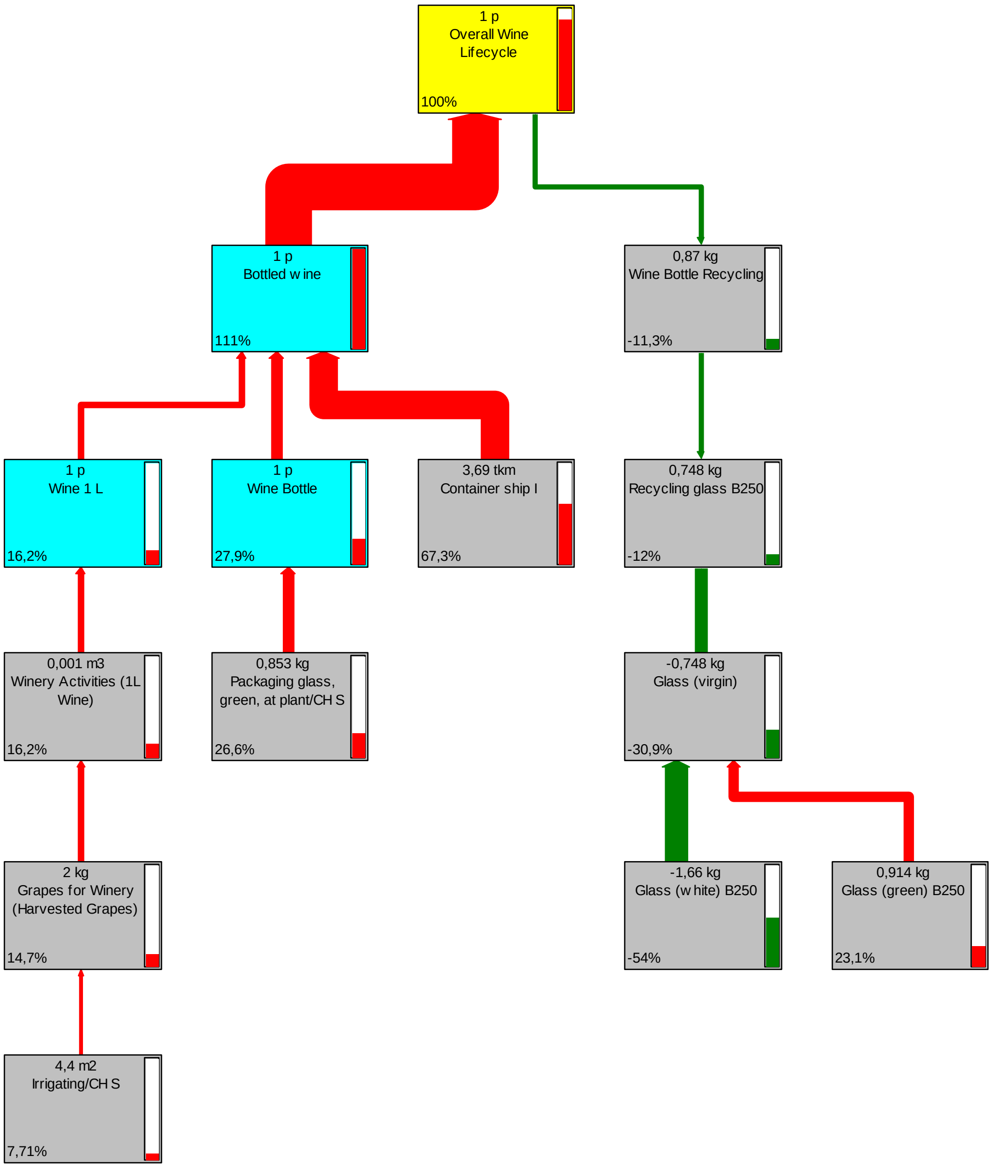


FIGURE 3: CHARACTERIZATION OF THE WINE FLOW CHART ACCORDING TO INORGANIC RESPIRATORY

‘

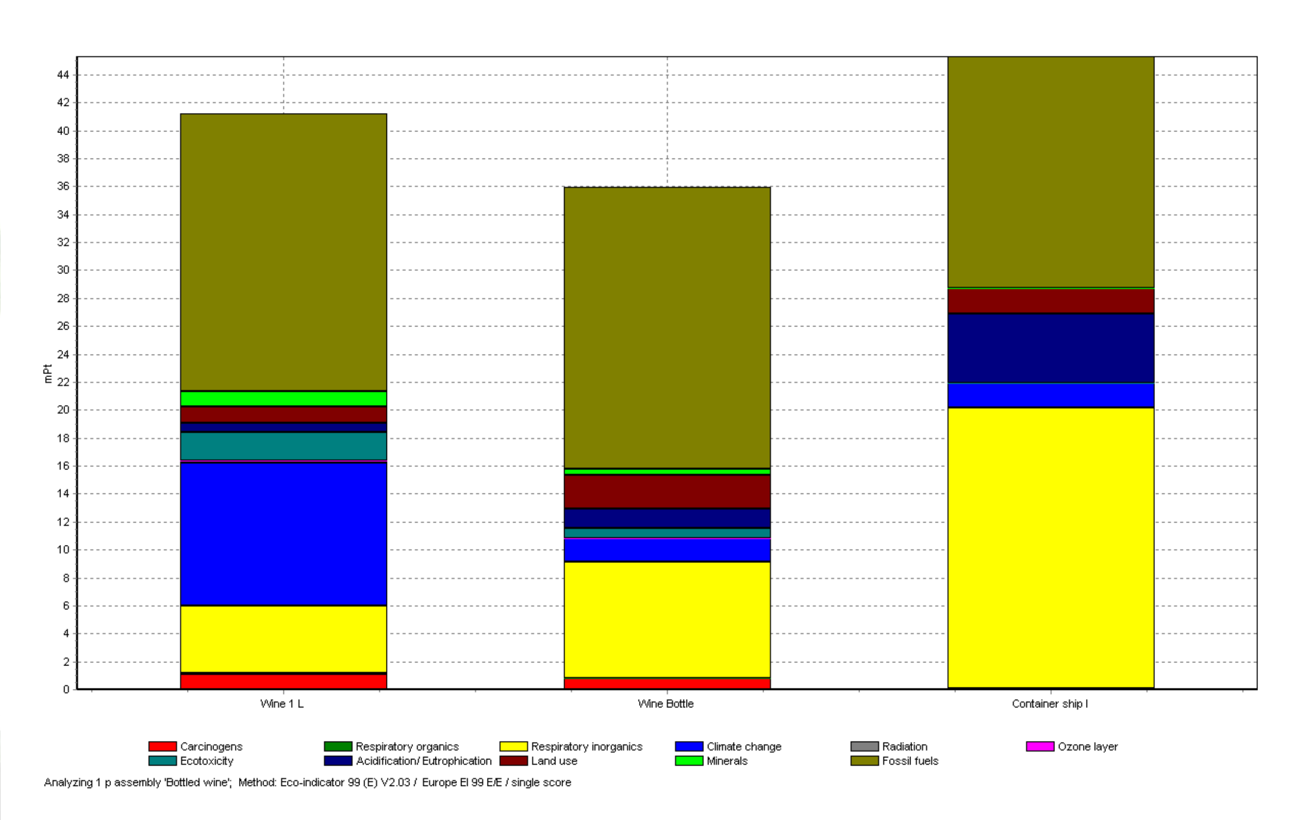


FIGURE 4: SINGLE SCORE ANALYSIS OF THE MAIN PROCESSES: GRAPES HARVESTING, WINERY AND TRANSPORT

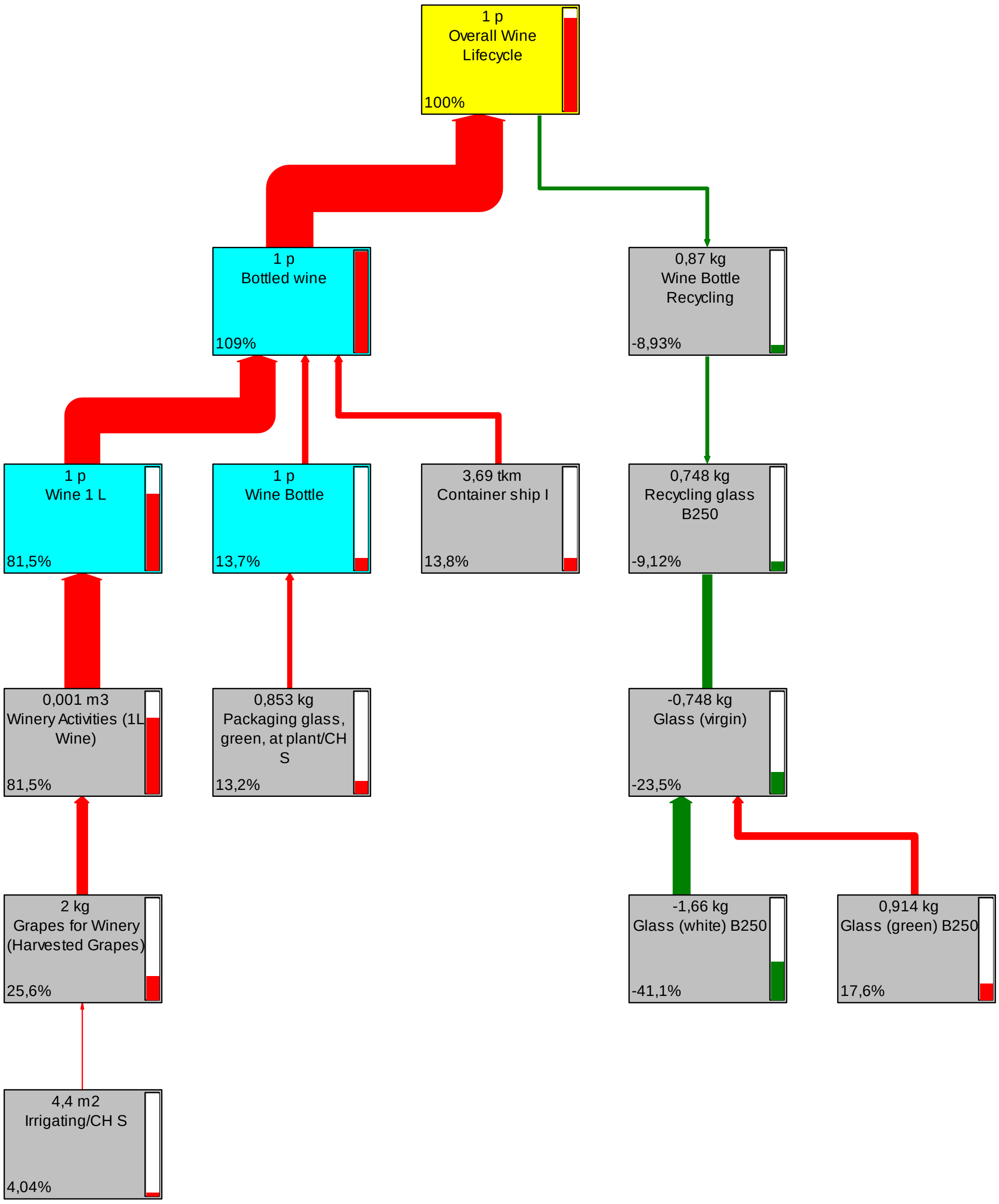


FIGURE 5: CHARACTERIZATION OF THE WINE FLOW CHART ACCORDING TO CLIMATE CHANGE.

APPENDIX D: ECO-WINE FIGURES FROM SIMAPRO

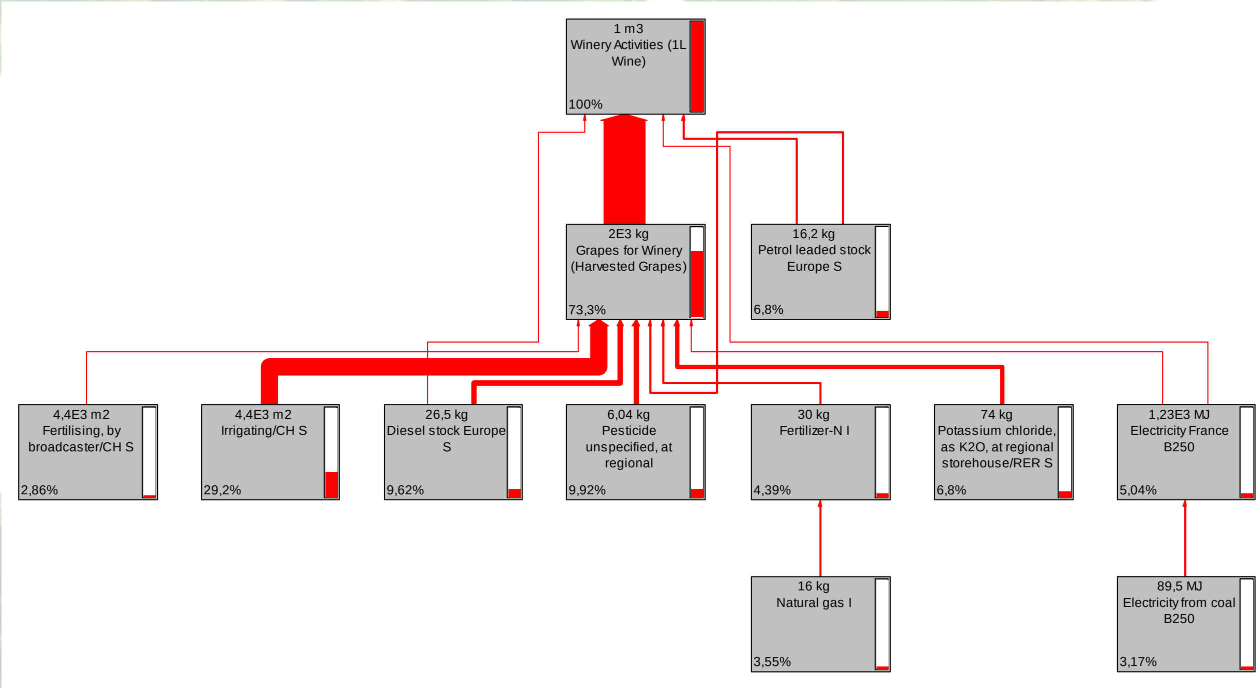


FIGURE 1: LIFE CYCLE OF THE WINE PRODUCTION STAGE

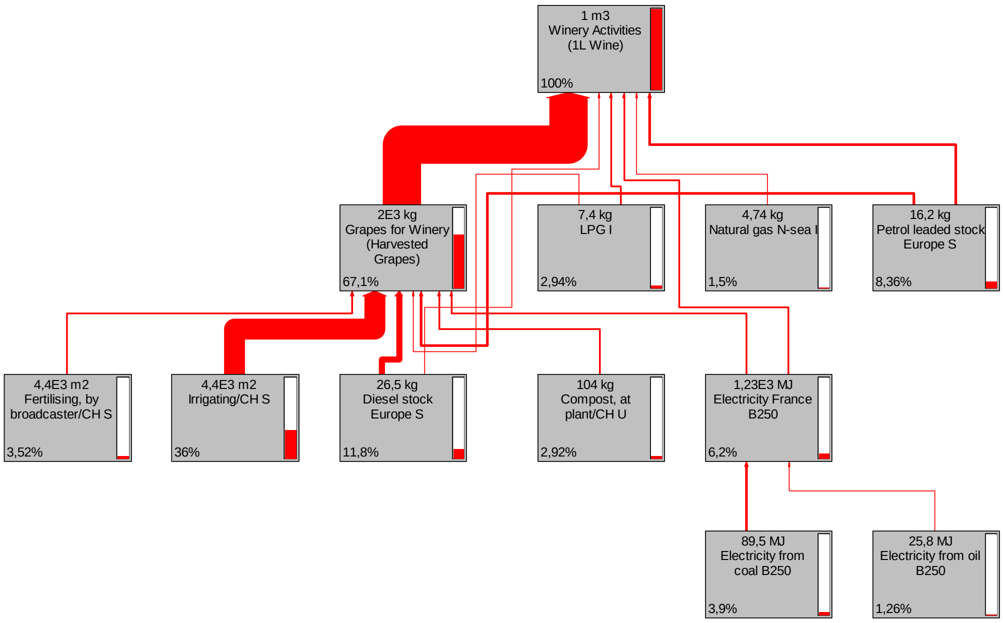


FIGURE 2: ECO-WINE FLOW CHART FOR WINE PRODUCTION STAGE

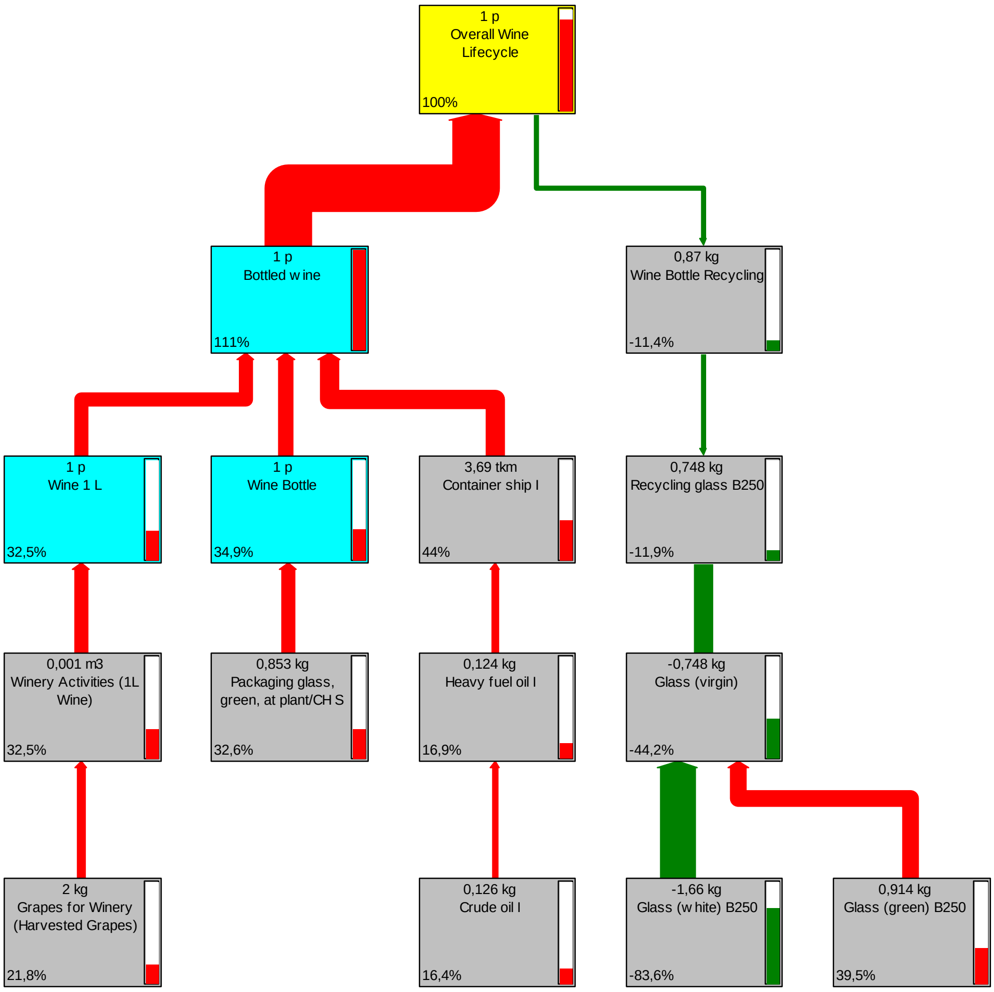


FIGURE 3: LIFE CYCLE OF ECO-WINE

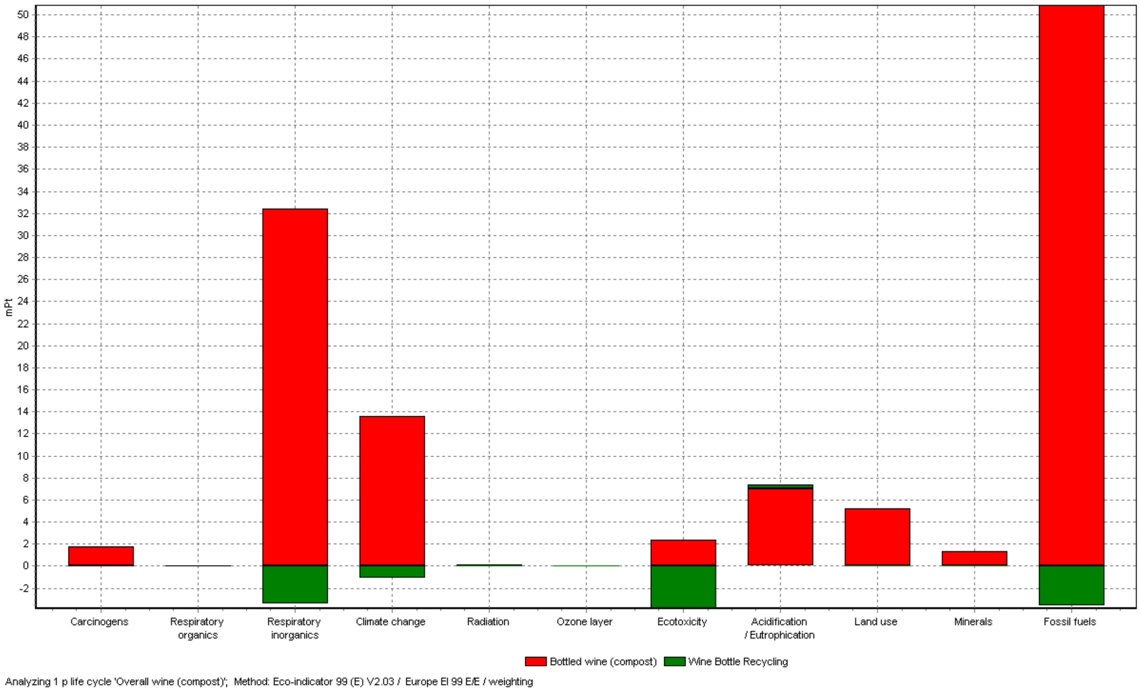


FIGURE 4: IMPACT CATEGORIES FOR ECO-WINE

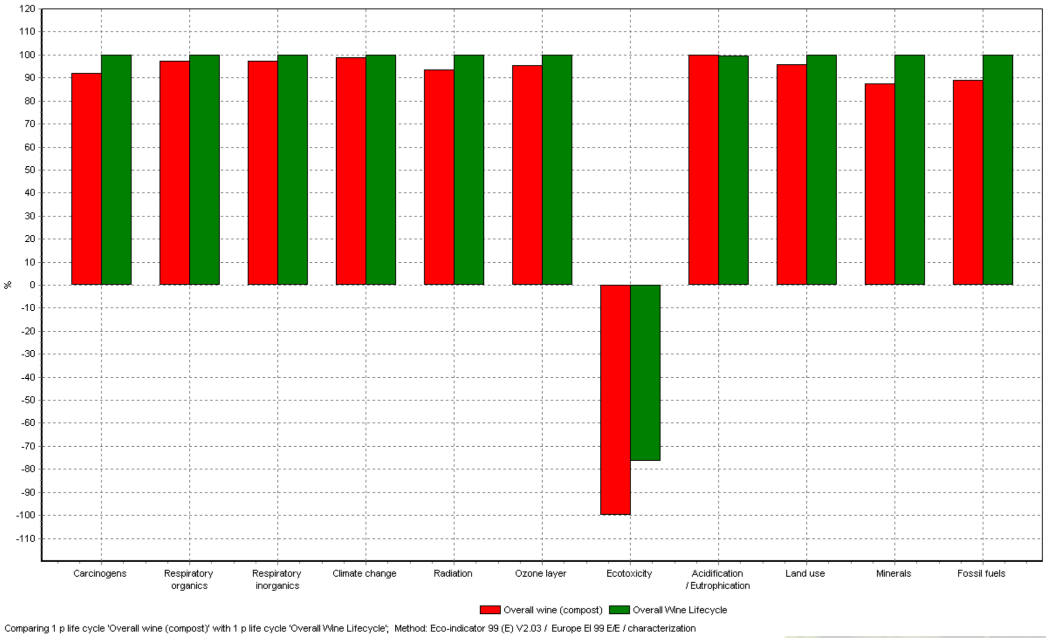
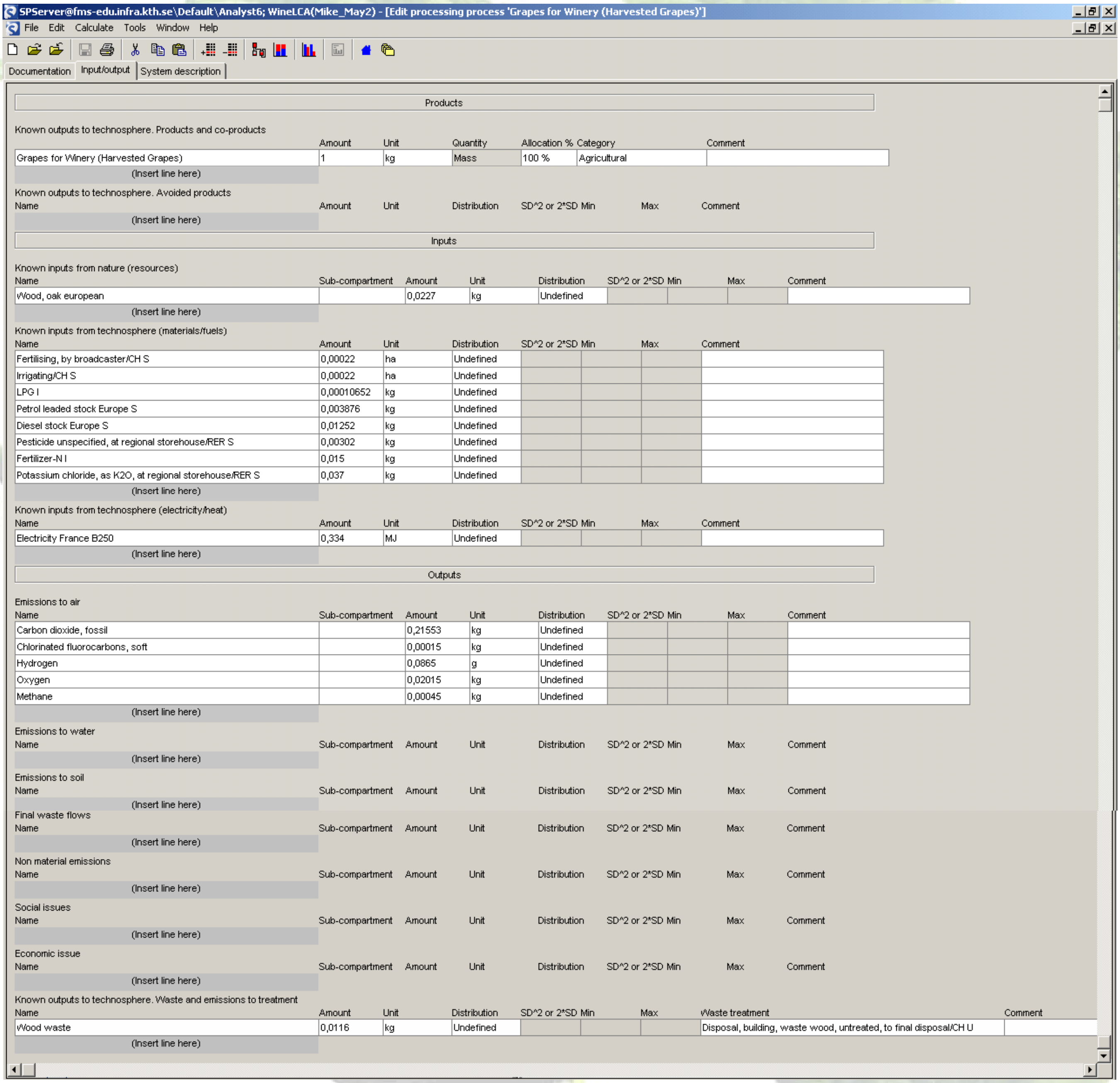


FIGURE 5: COMPARISON OF IMPACT CATEGORIES BETWEEN WINE(RED) AND ECO-WINE(GREEN).

APPENDIX E: DATA SHEET FOR GRAPES FOR WINERY (HARVESTED GRAPES)

SimaPro 6.0	Process	Date:	2006-05-17	Time:	10:40:55
Project: WineLCA(Mike_May2)					
Process					
Category type	Processing				
Process identifier	KTH.FMSX11687200008				
Type					
Name					
Time period	Unspecified				
Geography	Unspecified				
Technology	Unspecified				
Representativeness	Unspecified				
Multiple output allocation	Unspecified				
Substitution allocation	Unspecified				
Cut off rules	Unspecified				
Capital goods	Unspecified				
Boundary with nature	Unspecified				
Infrastructure	No				
Date	2006-05-02				
Record					
Generator					
Literature references					
Collection method					
Data treatment					
Verification					
Comment					
Allocation rules					
System description					
Products					
Grapes for Winery (Harvested Grapes)	1	kg	100 %	Agricultural	
Avoided products					
Resources					
Wood, oak european	0,0227	kg			
Materials/fuels					
Fertilising, by broadcaster/CH S	0,00022	ha			
Irrigating/CH S	0,00022	ha			
LPG I	0,00010652	kg			
Petrol leaded stock Europe S	0,003876	kg			
Diesel stock Europe S	0,01252	kg			
Pesticide unspecified, at regional storehouse/RER S	0,00302	kg			
Fertilizer-N I	0,015	kg			
Potassium chloride, as K2O, at regional storehouse/RER S	0,037	kg			
Electricity/heat					
Electricity France B250	0,334	MJ			
Emissions to air					
Carbon dioxide, fossil	0,21553	kg			
Chlorinated fluorocarbons, soft	0,00015	kg			
Hydrogen	0,0865	g			
Oxygen	0,02015	kg			
Methane	0,00045	kg			
Emissions to water					
Emissions to soil					
Final waste flows					
Non material emission					
Social issues					
Economic issues					
Waste to treatment					
Waste	Wood waste	0,0116	kg	Disposal, building, waste wood, untreated, to final disposal/CH U	

(SimaPro, 2006)



(SimaPro, 2006)