

Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Life Cycle Assessment and the New Zealand Wine Industry: A tool to support continuous environmental improvement

A thesis presented in partial fulfilment of the requirements for the degree of
Master of Environmental Management

in
Life Cycle Management

at Massey University, Wellington, New Zealand.

Martin Thomas Barry

2011



***“If we want things to stay as they are,
things will have to change”***

Giuseppe di Lampedusa, 1896 - 1957

ABSTRACT

As the marketplace becomes increasingly environmentally conscious, demonstration of environmental credentials and evidence of continuous improvement will likely become of increasing strategic and economic importance to New Zealand wine exporters. Keeping pace with such market changes will ensure local exporters remain competitive against other wine producing countries, and help secure their share in important foreign markets such as the UK.

This thesis uses Life Cycle Assessment (LCA) to identify how the New Zealand wine industry can improve its standard of environmental management and inform its practice of environmental labelling. Through the identification of environmental hotspots, use of sensitivity analysis, and normalisation of results, all using a product life cycle framework, this research provides the industry with some direction as to how to better measure, manage and reduce its environmental impact, and identifies various ways of improving the quality of information being conveyed to the consumer through environmental labelling.

This research shows environmental improvement opportunities lie particularly in the areas of packaging systems, frost protection, agrichemical application, waste management, energy efficiency in the winery, and crop regulation. It provides some evidence to indicate that the carbon footprint is not the most significant environmental impact in the wine life cycle, and that other environmental impacts should be considered in development of improved environmental management systems. It also highlights the importance of using a standardised methodology in environmental labelling programmes.

ACKNOWLEDGEMENTS

I would like to thank David Drysdale for his assistance in developing the GaBi model, and Amy Dawson for the ongoing support. Also thanks to Kathy Hamilton, and of course my supervisor Sarah McLaren.

TABLE OF CONTENTS

ABSTRACT	iii
ACKNOWLEDGEMENTS	iv
TABLE OF CONTENTS	v
LIST OF FIGURES	viii
LIST OF TABLES.....	x
LIST OF ABBREVIATIONS USED	xi
CHAPTER 1: INTRODUCTION.....	1
1.1 Aim	3
1.2 Research Questions and Objectives	4
1.3 Method and Approach.....	5
1.5 The LCA Case Study	6
1.6 Disciplinary Context	7
CHAPTER 2: LCA AND THE WINE INDUSTRY	8
2.1 What is Life Cycle Assessment?	8
2.2 The LCA Method.....	8
2.2.1 Phase 1 - Goal and Scope Definition	9
2.2.2 Phase 2 - Life Cycle Inventory Analysis.....	12
2.2.3 Phase 3 - Life Cycle Impact Assessment.....	12
2.2.4 Phase 4 - Interpretation	15
2.3 Applications of LCA	16
2.4 Advantages of LCA	17
2.5 Disadvantages of LCA.....	18
2.6 LCA Studies in the Wine Industry.....	18
2.6.1 System Boundaries	19
2.6.2 Environmental Hotspots.....	20
2.6.3 Variability in GWP Results.....	21
2.6.4 Normalisation.....	22
CHAPTER 3: ENVIRONMENTAL MANAGEMENT AND THE WINE INDUSTRY	24

3.1 Drivers Influencing Environmental Management in the Wine Industry	24
3.1.1 Changing Consumer Preferences.....	25
3.1.2 Increasing Information Demand from Importers	26
3.1.3 Market Competition	27
3.1.4 Regulation	29
3.2 Sustainable Winegrowing New Zealand	30
3.3 Greenhouse Gas Accounting Methods.....	31
3.3.1 Company-level GHG Accounting.....	31
3.3.2 Product-level GHG Accounting	34
3.4 Application of GHG Management Approaches in the New Zealand Wine Industry	35
3.3.1 GHG Product Accounting Guidelines for the Wine Industry	36
3.3.2 International Wine Industry GHG Protocol and Accounting Tool	36
3.5 Environmental Impact Quotient Method.....	37
3.6 Summary.....	37
CHAPTER 4: ENVIRONMENTAL LABELLING AND THE WINE INDUSTRY	39
4.1 Company-Level Schemes.....	39
4.1.1 Carbon Neutrality	40
4.2 Product Labelling.....	41
4.2.1 ISO Environmental Labelling Standards	41
4.2.2 Carbon Neutrality Labelling	45
4.3 Issues Associated with Product Carbon Labelling.....	46
4.4 Summary.....	47
CHAPTER 5: THE LCA CASE STUDIES	48
5.1 Goal and Scope Definition	48
5.1.1 Goal Definition	48
5.1.2 Scope Definition.....	49
5.2 Life Cycle Inventory Analysis (LCI).....	56
5.2.1 Grape Growing.....	58
5.2.2 Wine Making	63
5.2.3 Packaging.....	68
5.2.4 Distribution to Consumer	72
5.3 Life Cycle Impact Assessment (LCIA)	74

5.3.1 General Findings	74
5.3.2 Results by Impact Category.....	76
5.3.3 Normalisation.....	87
5.4 Sensitivity Analysis	89
5.4.1 Grape Growing.....	90
5.4.2 Wine Making	93
5.4.3 Packaging.....	94
5.4.4 Packaging and Distribution to Consumer.....	95
5.4.5 Distribution to Consumer.....	98
5.5 Interpretation	99
5.5.1 The Vineyard	99
5.5.2 The Winery	101
5.5.3 Packaging.....	104
5.5.4 Summary of Activities.....	105
CHAPTER 6: DISCUSSION AND CONCLUSION	109
6.1 Implications for Environmental Management in the Wine Industry	109
6.1.1 Frost Management	110
6.1.2 Use of Agrichemicals	110
6.1.3 Sheep Grazing	110
6.1.4 Management of Yields.....	111
6.1.5 Energy Efficiency in the Winery.....	111
6.1.6 Lees Waste Management.....	111
6.1.7 Packaging Systems.....	112
6.1.8 Export Markets.....	114
6.1.9 SWNZ and Carbon Footprinting.....	114
6.2 Implications for Environmental Labelling in the Wine Industry	116
CHAPTER 7: CONCLUSION.....	118
AREAS FOR FUTURE RESEARCH	119
APPENDIX I- DESCRIPTION OF THE IMPACT CATEGORIES USED	120
REFERENCES	122

LIST OF FIGURES

Figure 1: Value of New Zealand wine exports between 1999 and 2009. Source (NZWINE, 2010a)	2
Figure 2: Illustration of the four phases of the LCA process as defined by the International Standards Organisation. Source (ISO, 2006)	9
Figure 3: Four common options for defining system boundaries used in Life Cycle Assessment. Based on (PE, 2009)	11
Figure 4: Taking data from the Life Cycle Inventory, going through steps of classification and characterisation, onto the Life Cycle Inventory Analysis. Adapted from (PE, 2009)	14
Figure 5: Global Warming Potential for product-at-gate reported in a number of studies.....	22
Figure 6: Logo used by certified wineries and vineyards.....	29
Figure 7: Logo used by certified wineries and vineyards under the Integrated Production of Wine scheme	29
Figure 8: Logo used by certified wineries and vineyards under the Sustainable Winegrowing programme	30
Figure 9 Mobius wine bottle featuring the Carbon Reduction Label	42
Figure 10: An example of a Type II label from the Epsom Group	43
Figure 11: Illustration of the foreground and background systems in this study.....	52
Figure 12: Flow chart of the product system as defined in this study.....	57
Figure 13: Relative contribution of each life cycle stage to the eleven impact categories.....	75
Figure 14: Contribution of each life cycle stage to Global Warming Potential in both wineries.....	76
Figure 15: Contribution of each life cycle stage towards Ozone Depletion Potential in both wineries	77
Figure 16: Contribution of each life cycle stage towards Abiotic Depletion Potential in both wineries	78
Figure 17: Contribution of each life cycle stage towards Primary Energy Consumption in both wineries.	79
Figure 18: Contribution of each life cycle stage towards Photochemical Ozone Creation Potential in both wineries	80
Figure 19: Contribution of each life cycle stage towards Acidification Potential in both wineries.....	81
Figure 20: Contribution of each life cycle stage towards Eutrophication Potential in both wineries.....	82
Figure 21: Contribution of each life cycle stage towards Marine Aquatic Ecotoxicity Potential in both wineries	83
Figure 22: Contribution of each life cycle stage towards Fresh Water Aquatic Ecotoxicity Potential in both wineries	84
Figure 23: Contribution of each life cycle stage towards Terrestrial Ecotoxicity Potential in both wineries	85
Figure 24: Contribution of each life cycle stage towards Human Toxicity Potential in both wineries.....	86
Figure 25: Normalised data results for both wineries against the CML 2001 OECD reference index value	87
Figure 26: Sensitivity to a doubling of frost events in various impact category values for the grape growing life cycle stage	90

Figure 27: Sensitivity of Freshwater Aquatic Ecotoxicity Potential and Terrestrial Ecotoxicity Potential in the grape growing stage to a 50% increase in field spray emissions.....	91
Figure 28: Sensitivity of Global Warming Potential in the grape growing stage to the inclusion and exclusion of the GHG impacts associated with sheep grazing in the system boundary	92
Figure 29: Sensitivity to a 50% reduction in harvest yield in various impact category values for the product-at-gate.....	93
Figure 30: Sensitivity to a 15% increase in electricity consumption in the winery in impact category values for the wine making stage.....	93
Figure 31: Sensitivity of Global Warming Potential in the wine making stage to composting lees waste	94
Figure 32: Sensitivity of Global Warming Potential over the total life cycle to changes in the greenhouse gas emissions factor for glass bottle production	95
Figure 33: Sensitivity of using the PET bottle in the impact category values over the total life cycle	96
Figure 34: Sensitivity of bulk shipping in various impact category values over the total life cycle.....	97
Figure 35: Sensitivity of using lightweight glass bottles in various impact category values over the total life cycle.....	97
Figure 36: Sensitivity to a 50% reduction in shipping distance in the impact category values for the distribution to consumer stage	98
Figure 37: Change in total Global Warming Potential that would hypothetically result from the same studied wine product being produced in different countries	103

LIST OF TABLES

Table 1: A hypothetical life cycle inventory table for a study with a functional unit of 2,000 oranges.....	12
Table 2: Most common greenhouse gases and their respective Global Warming Potentials.	32
Table 3: Data sources used for the various materials and activities throughout the studied life cycle	53
Table 4: Default manufacturing energy requirements for agrichemicals. Source (Green, 1987).	59
Table 5: Inventory table for the grape growing life cycle stage.....	62
Table 6: Inventory table for entire Sauvignon Blanc production during the wine making life cycle stage	67
Table 7: Inventory table for wine additives used in the wine making life cycle stage	68
Table 8: Various greenhouse gas emission factors used for glass bottle production in the literature.....	69
Table 9: Inventory table for the packaging life cycle stage	71
Table 10: A range of data sources and their respective shipping emissions factors for container ships ...	72
Table 11: Transportation distances for the distribution to consumer life cycle stage	73
Table 12: Main contributing activities to Global Warming Potential in both wineries	77
Table 13: Main contributing activities to Ozone Depletion Potential in both wineries	78
Table 14: Main contributing activities to Abiotic Depletion Potential in both wineries	79
Table 15: Main contributing activities to Primary Energy Consumption in both wineries	80
Table 16: Main contributing activities to Photochemical Ozone Creation Potential in both wineries	81
Table 17: Main contributing activities to Acidification Potential in both wineries	82
Table 18: Main contributing activities to Eutrophication Potential in both wineries	83
Table 19: Main contributing activities to Fresh Water Aquatic Ecotoxicity Potential in both wineries	85
Table 20: Main contributing activities to Terrestrial Ecotoxicity Potential in both wineries	86
Table 21: Number of frost events in different wine growing regions of New Zealand, with a corresponding hypothetical Global Warming Potential for the product-at-gate.....	100
Table 22: Various hypothetical harvest yields with its effect on Global Warming Potential in the modelled wine product.....	101
Table 23: Percentage reduction in Global Warming Potential for a range of environmental improvement options.....	106
Table 24: Percentage reduction in Acidification Potential for a range of environmental improvement options.....	107
Table 25: Percentage reduction in Abiotic Depletion Potential for a range of environmental improvement options.....	108
Table 26: Potential greenhouse gas reductions the industry might achieve under a range of packaging scenarios	113
Table 27: Description of the various impact categories used in this LCA study. Based on Guinée (2002).	120

LIST OF ABBREVIATIONS USED

ADP	Abiotic Depletion Potential
AP	Acidification Potential
CF	Characterisation factor
EP	Eutrophication Potential
EPD	Environmental Product Declaration
FAETP	Freshwater Aquatic Ecotoxicity Potential
GHG	Greenhouse Gas
GWP	Global Warming Potential
HTP	Human Toxicity Potential
IPCC	Intergovernmental Panel on Climate Change
IWCC	International Wine Carbon Calculator
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MAETP	Marine Aquatic Ecotoxicity Potential
MAF	New Zealand Ministry of Agriculture and Forestry
NI	North Island (case study) winery
ODP	Ozone Depletion Potential
PAG	Product-at-gate
PCF	Product Carbon Footprint
POCP	Photochemical Ozone Creation Potential
SI	South Island (case study) winery
TETP	Terrestrial Ecotoxicity Potential
WRAP	The British Waste and Resources Action Programme