ENVIRONMENTAL LIFE CYCLE ASSESSMENT OF NOMACORC WINE CLOSURES

EXECUTIVE SUMMARY

Study conducted for Nomacorc's European and American facilities for the years 2008 and 2011.

All calculated or aggregated results produced using GaBi Life Cycle Assessment Software (PE International AG, Stuttgart, May 2011).

Title: Environmental Life Cycle Assessment of Nomacorc Wine Closures

Date: March 2013

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Executive Summary

Introduction and Background

Nomacorc is the world's largest producer of engineered wine closures. Nomacorc closures were conceived as a solution to the inconsistencies and TCA contamination prevalent in natural and technical cork wine closures. All Nomacorc closures are manufactured using a patented co-extrusion process that creates closures with a foamed core and an outer skin.

In 2008, the company conducted its first carbon footprint assessment of Nomacorc closures, demonstrating a commitment to understanding, and reducing the environmental impact of its products. More recently in 2012, Nomacorc released its first Corporate Social Responsibility report, disclosing the company's overall performance on economic, environmental and social sustainability measures for the year 2011.

This study is Nomacorc's first life cycle assessment (LCA). The LCA methodology looks beyond the carbon footprint by examining a broad range of environmental impacts related to each phase of production, use and disposal of Nomacorc closures.

Scope of the Study

This study focuses on Nomacorc's major product line, launched as "Classic" in 2008 and now branded as "Classic+". This study tracks improvements in product formulation made to this line between 2008 and 2011, as well as improvements in manufacturing and transportation efficiency made by the company during the same period. The data used for this analysis covers both of Nomacorc's major manufacturing facilities; one located in the U.S. and the other in Belgium. The U.S. and Belgium facilities both use the same closure formulation.

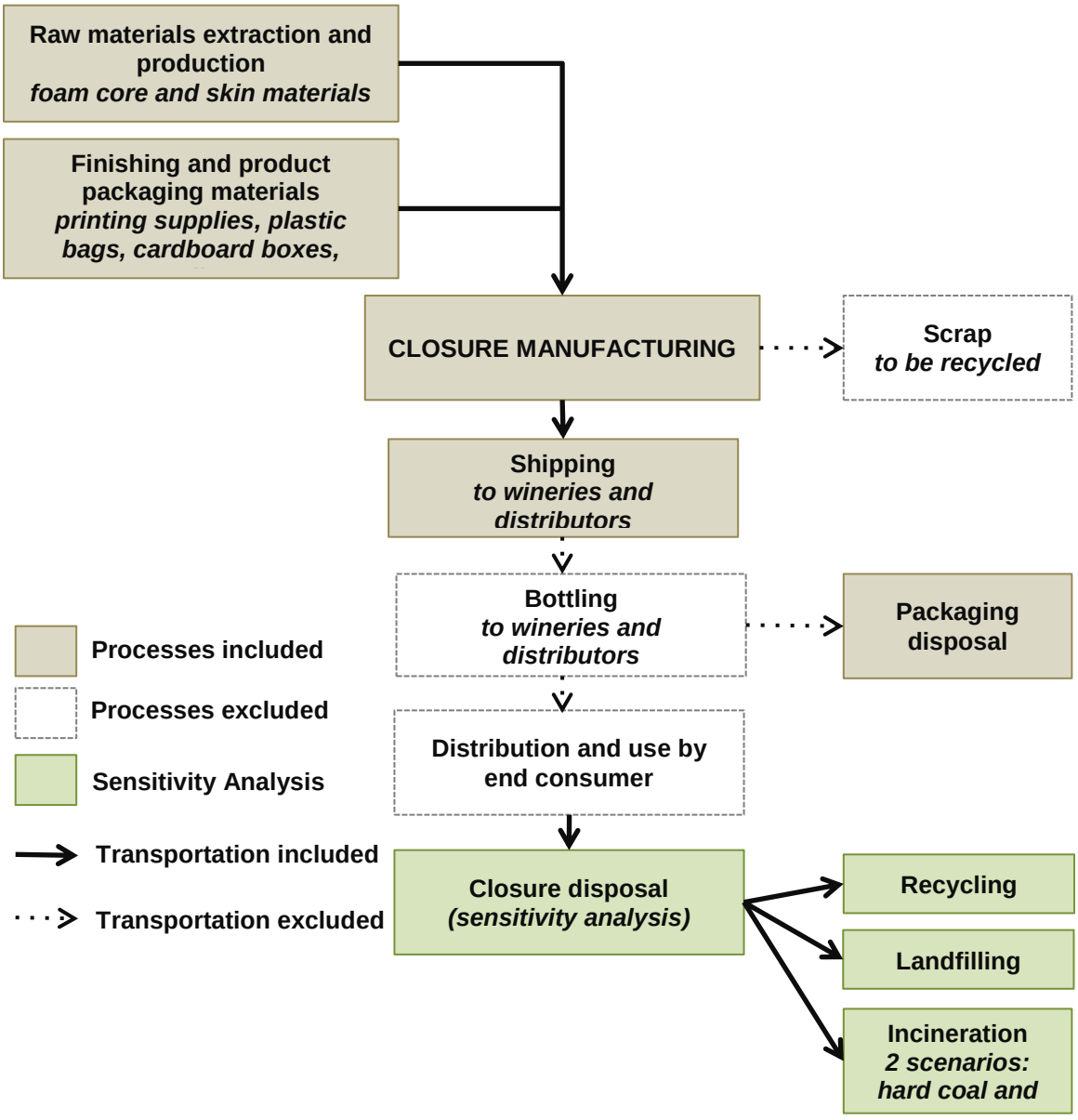
Four systems (also called "reference flows") were compared in this study:

- Nomacorc Classic closures manufactured in Belgium in 2008 (Nomacorc Belgium 2008)
- Nomacorc Classic+ closures manufactured in Belgium in 2011 (Nomacorc Belgium 2011)
- Nomacorc Classic closures manufactured in the U.S. in 2008 (Nomacorc U.S. 2008)
- Nomacorc Classic+ closures manufactured the U.S. in 2011 (Nomacorc U.S. 2011)

The core study measures the environmental impacts for every step of the life cycle of a Nomacorc closure from "cradle" (raw materials extraction), to "gate" (the distribution of finished closures to customers). Because the product is consumed in a variety of

different countries, a number of possible scenarios exist for Nomacorc closures at end-of-life ("grave"), including incineration, landfilling and recycling. Therefore, rather than including end-of-life in the core study, this study tests three different potential end-of-life paths in a sensitivity analysis. The sensitivity analysis enables us to quantify the environmental impacts associated with each path and identify preferable end-of-life options for Nomacorc closures.

The flow chart below illustrates the boundaries of the assessment. All four systems studied share the same boundaries.



The following table depicts the four systems (reference flows) assessed in this study.

	Nomacorc Belgium 2008	Nomacorc Belgium 2011	Nomacorc U.S. 2008	Nomacorc U.S. 2011
Product name and size	Classic 37mm	Classic+ 37mm	Classic 37mm	Classic+ 37mm
Country of manufacturing	Belgium	Belgium	United States	United States
Reference year	2008	2011	2008	2011
Technology	Nomacorc utilizes patented state-of-the-art co-extrusion technology; all machines date from 2003 and are the same in the U.S. and Belgium.			
Shipping of raw materials from suppliers	2225kg.km by truck; 32,513kg.km by container ship	795kg.km by truck; 1917kg.km by container ship	3954kg.km by truck; 2626kg.km by container ship	2325kg.km by truck; 12,106kg.km by container ship
Shipping of finished products to customers	Nomacorc Belgium to Bordeaux region (1000km; 100% truck)	Nomacorc Belgium to Bordeaux region (1000km; 100% truck)	Nomacorc U.S. to Napa region (4600km; 100% truck)	Nomacorc U.S. to Napa region (4600km; 80% truck, 20% rail)
End-of-life (sensitivity analysis)	not modeled	incineration, landfill, and recycling scenarios modeled for EU*	not modeled	not modeled

**results presented in the sensitivity analysis section*

Each of the above reference flows was assessed using six environmental impact categories from the CML 2001 impact assessment methodology and two inventory values, as listed in the tables below:

Impact Category	Abbreviation	Units	Description
Abiotic Depletion Potential (elements)	ADP elements	kg Sb-Equiv.	Measures global depletion of non-renewable minerals and fossil fuels
Acidification Potential	AP	kg SO2-Equiv.	Measures the negative impact on natural systems from acid depositions caused by atmospheric pollution
Eutrophication Potential	EP	kg Phosphate-Equiv.	Excessive levels of nutrients in aquatic or terrestrial environments originating mainly from nitrogen and phosphorus in wastewaters and fertilizers
Global Warming Potential (100 years)	GWP	kg CO2-Equiv.	Relative measure of the contribution of greenhouse gases to global warming
Ozone Layer Depletion Potential	ODP	kg R11-Equiv.	Measures the relative amount of degradation a substance can cause to the ozone layer

Photochemical Ozone Creation Potential	POCP	kg Ethene-Equiv.	Measures the contribution of volatile organic compounds (VOCs) and other substances to ground-level ozone, also known as smog (toxic to humans in high concentrations).

Inventory Value	Abbreviation	Units	Description
Energy (net calorific value)	Energy	MJ	Represents the primary energy demand (PED), measured as the upper heating value (UHV); includes non-renewable and renewable primary energy resources
Water	Water	L	Accounts for a global balance between 16 specific sources and destinations of water.

Selected Results and Conclusions

Results are presented in a non-exhaustive and aggregated fashion in three user-defined categories:

- Consumables – includes the impacts generated by raw materials in the co-extrusion of the closure, its finishing, packaging and disposal;
- Shipping – includes all impacts generated during the shipping of goods from suppliers to Nomacorc factories, and during the shipping of finished products to customers;
- Energy Consumption – includes electricity and gas consumption during the manufacturing process.

Consumables, representing the extraction and production of raw materials, account for the largest proportion of the total environmental impacts in all four reference flows studied.

Results for Nomacorc's Belgium Facility: 2008 and 2011

The table below displays results from the environmental impact assessment of one thousand Classic 37mm closures produced in Nomacorc Belgium in 2008 modeled after PE databases.

IMPACT CATEGORY	TOTAL	Consumables	Shipping	Energy consumption
ADP elements (kg Sb-Equiv.)	2.49E-06	2.36E-06	6.16E-08	6.22E-08
AP (kg SO2-Equiv.)	5.63E-02	4.11E-02	1.29E-02	2.19E-03
EP (kg Phosphate-Equiv.)	4.83E-03	3.02E-03	1.59E-03	2.19E-04

GWP (kg CO2-Equiv.)	13.00	11.09	0.85	1.05
ODP (kg R11-Equiv.)	4.30E-07	3.77E-08	4.95E-10	3.92E-07
POCP (kg Ethene-Equiv.)	6.89E-03	6.72E-03	-2.73E-05	2.00E-04
Net energy (MJ)	441.94	392.86	11.18	37.90
Water (L)	16.14	16.53	0.00	-0.40

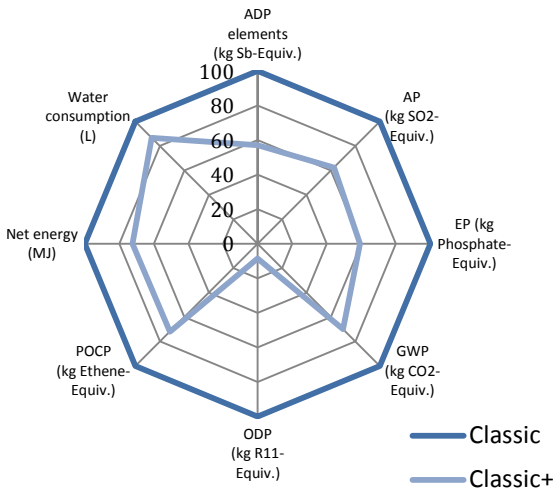
The following table displays results from the environmental impact assessment of one thousand Classic 37mm closures produced in Nomacorc Belgium in 2011 modeled after PE databases.

IMPACT CATEGORY	TOTAL	Consumables	Shipping	Energy consumption
ADP elements (kg Sb-Equiv.)	1.42E-06	1.86E-06	1.51E-08	-4.57E-07
AP (kg SO2-Equiv.)	3.51E-02	3.31E-02	1.97E-03	9.61E-05
EP (kg Phosphate-Equiv.)	2.86E-03	2.47E-03	3.81E-04	7.91E-06
GWP (kg CO2-Equiv.)	9.09	8.72	0.33	0.04
ODP (kg R11-Equiv.)	3.65E-08	3.62E-08	1.34E-10	1.87E-10
POCP (kg Ethene-Equiv.)	4.96E-03	5.36E-03	-4.19E-04	1.81E-05
Net energy (MJ)	319.87	312.65	4.50	2.71
Water (L)	13.99	13.98	0.01	0.00

The results for closures from Nomacorc's Belgium facility show improvements across all environmental impact categories between 2008 and 2011. Reasons for these improvements include:

- Product formulation: The 2011 Classic+ closure is less dense than the 2008 Classic closure, requiring less material to manufacture
- Raw material supplier: The Belgium facility switched from a U.S. raw material supplier to a local raw material supplier
- Shipping efficiencies: The 2011 Classic+ closure is lighter than the 2008 Classic closure, which improves the efficiency of transporting the closures to customers
- Alternative Energy Use: The electricity supplied to the Belgium facility in 2011 originated 100% from wind power

The graph below depicts the relative percent improvement between Classic closures produced in 2008 and Classic+ closures produced in 2011 in Nomacorc's Belgium facility for selected environmental indicators. (LCI data collected in 2008 and 2011, respectively).



Results for Nomacorc's U.S. Facility: 2008 and 2011

The table below displays results from the environmental impact assessment of one thousand Classic 37mm closures produced in Nomacorc U.S. in 2008 modeled after USLCI and PE databases. *

IMPACT CATEGORY	TOTAL	Consumables	Shipping	Energy consumption
ADP elements (kg Sb-Equiv.)	2.68E-06	2.36E-06	2.01E-07	1.14E-07
AP (kg SO2-Equiv.)	1.90E-01	1.59E-01	9.19E-03	2.19E-02
EP (kg Phosphate-Equiv.)	5.34E-03	2.47E-03	1.94E-03	9.27E-04
GWP (kg CO2-Equiv.)	13.76	7.90	1.89	3.97
ODP (kg R11-Equiv.)	4.26E-07	3.79E-08	1.40E-09	3.86E-07
POCP (kg Ethene-Equiv.)	1.19E-02	1.31E-02	-2.38E-03	1.16E-03
Net energy (MJ)	486.89	385.56	26.25	75.07
Water (L)	15.73	16.48	0.02	-0.78

The following table displays results from the environmental impact assessment of one thousand Classic+ 37mm closures produced in Nomacorc U.S. in 2011 modeled after USLCI and PE databases. *

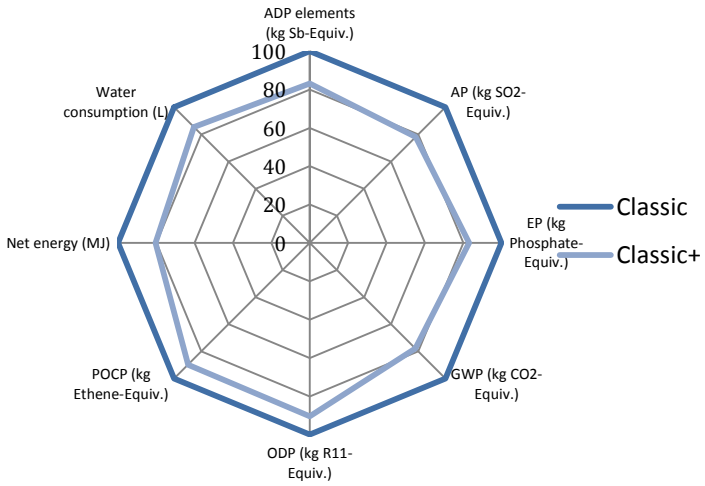
IMPACT CATEGORY	TOTAL	Consumables	Shipping	Energy consumption
ADP elements (kg Sb-Equiv.)	2.22E-06	1.89E-06	1.55E-07	1.84E-07
AP (kg SO2-Equiv.)	1.51E-01	1.28E-01	8.58E-03	1.46E-02
EP (kg Phosphate-Equiv.)	4.45E-03	2.06E-03	1.73E-03	6.52E-04
GWP (kg CO2-Equiv.)	10.63	6.24	1.47	2.92
ODP (kg R11-Equiv.)	3.85E-07	3.64E-08	1.08E-09	3.48E-07
POCP (kg Ethene-Equiv.)	1.01E-02	1.05E-02	-1.25E-03	7.99E-04
Net energy (MJ)	391.49	308.89	20.28	62.32
Water (L)	13.45	14.16	0.02	-0.73

**Results for the U.S. were modeled using a combination of PE and USLCI datasets. USLCI datasets are specific to technologies used in North America, and provide a more accurate representation of the technology and feedstock mix for raw materials used in Nomacorc's U.S. facility. For this reason, the formulation of the closure (represented under consumables) was modeled using the USCLI datasets. Shipping and energy consumption are modeled using datasets from PE. Results for ADP and Water were assessed using PE datasets only, as the USLCI database used lacks a complete inventory of the elements affecting these indicators. Note that although most of the data in the USLCI database have undergone some sort of review, the database as a whole has not yet undergone a formal validation process.*

Results for the U.S. facility also show improvements across all environmental impact categories between 2008 and 2011. As was the case in the Belgium facility, closures from the U.S. facility were less environmentally impactful due to a less dense product formulation requiring less material to manufacture, and the shipping efficiencies associated with a lighter product. Additional reasons for improvements specific to the U.S. facility include:

- Rail shipping: In 2011, 20% of finished products were shipped to customers by rail, offsetting the need for transport by truck

The graph below depicts the relative percent improvement between Classic closures produced in 2008 and Classic+ closures produced in 2011 in Nomacorc's U.S. facility for selected environmental indicators. (LCI data collected in 2008 and 2011, respectively).



End-of-life

The end-of-life of the closures influences the LCA results in a significant way. A sensitivity analysis was conducted in order to evaluate the differences in environmental impacts from several waste management scenarios.

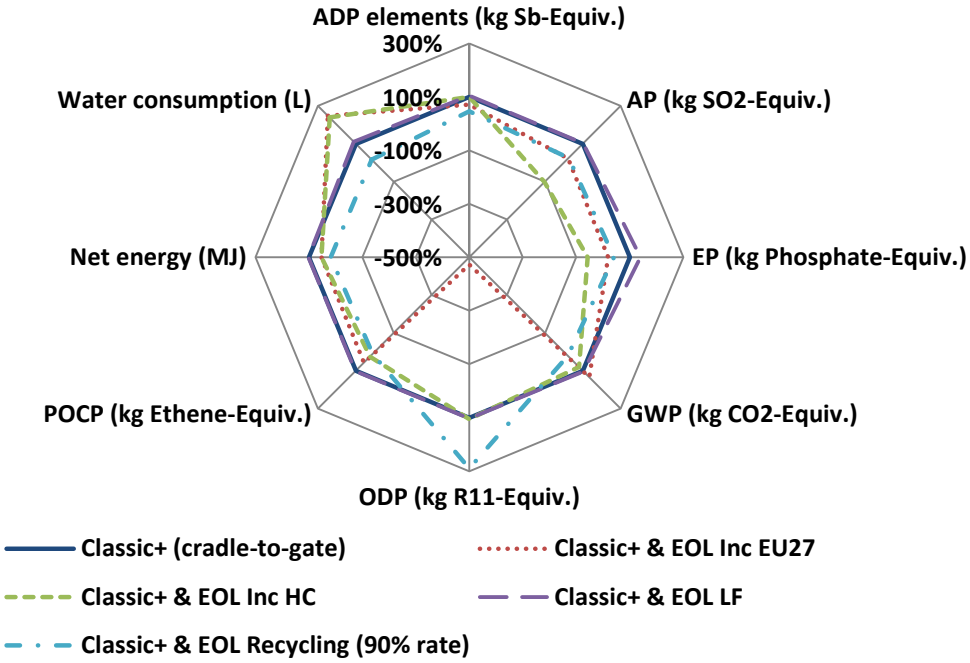
The analysis revealed that recycling is the most beneficial disposal scenario, but its overall contribution to avoiding environmental impacts depends on the closure's recyclability rate (i.e. the proportion of useful material that can be extracted from the material that reaches the recycling process). If incinerated, Nomacorc closures are a valuable source of energy, due to their heat content. Depending on the efficiency of incinerators, and if the source of fuel replaced is hard coal, incineration can offset some of the environmental impacts in certain categories created in manufacturing and shipping the closure. In the landfill, LDPE-based closures behave as inert material, creating only very slight environmental impact increases across all impact categories.

The table below shows LCA results according to waste management scenarios for a Classic+ closure (modeled after European specific datasets).

IMPACT CATEGORY	Classic+ (cradle-to-gate)	Incineration (EU 27)*	Incineration (hard coal)	Landfill	Recycling
ADP elements (kg Sb-Equiv.)	1.42E-06	9.97E-07	1.41E-06	1.48E-06	6.56E-07
AP (kg SO2-Equiv.)	3.51E-02	7.80E-03	-3.60E-02	3.61E-02	8.92E-03
EP (kg Phosphate-Equiv.)	2.86E-03	5.43E-04	-1.65E-03	4.00E-03	1.17E-03
GWP (kg CO2-Equiv.)	9.09	12.16	7.28	9.42	1.96
ODP (kg R11-Equiv.)	3.65E-08	-1.72E-07	3.84E-08	3.76E-08	1.06E-07
POCP (kg Ethene-Equiv.)	4.96E-03	2.85E-03	1.25E-03	5.09E-03	5.51E-04
Net energy (MJ)	319.87	168.51	168.76	324.94	59.10
Water (L)	13.99	34.67	33.42	15.57	2.23

**EU27 refers to the average energy grid mix from the 27 member countries of the European Union used during system expansion*

The graph below depicts the relative impact of each end-of-life scenario (cradle-to-grave), compared to the cradle-to-gate results.



Conclusions

The study revealed a number of important conclusions to guide Nomacorc in future product development. Key takeaways include:

- Improvements to product formulation carried out in Belgium and the U.S. between 2008 and 2011 have led to significant environmental improvements across all impact categories.
- Efficiencies achieved in manufacturing and transportation, as well as increased use of alternative energy (wind power in Belgium) and alternative modes of transportation (rail distribution in the U.S.), have supported environmental improvements between 2008 and 2011.
- Raw materials extraction and product manufacturing account for the largest share of environmental impacts from Nomacorc closures. Therefore, Nomacorc's ongoing efforts to reduce product density while maintaining or enhancing technical features are important to overall product sustainability.
- Recycling is the most environmentally preferable end-of-life scenario for Nomacorc closures. Though a fairly inert process, landfilling should be a last resort as it offers no potential for materials or energy recovery. Incineration with energy recovery may confer some environmental benefit over landfilling across certain indicators, depending on the feedstock avoided.