

# **CARBON FOOTPRINT ANALYSIS ON TRU ORGANIC SPIRITS**

**Final Report**

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**CONFIDENTIAL**

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## CARBON FOOTPRINT ANALYSIS – TRU ORGANIC SPIRITS

### I INTRODUCTION

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In 2004, husband-and-wife team Melkon Khosrovian and Litty Mathew founded Los Angeles-based Modern Spirits after friends and family began asking to buy the subtle, complex vodkas Melkon had created for his then-fiancée (who hated vodka) to sip at family meals. With food-friendly flavors like Black Truffle, Celery Peppercorn and Candied Ginger, the couple set out to change what people thought of the relationship between spirits and food. Modern Spirits was subsequently named as one of the top 50 spirits in 2006 by Wine Enthusiast and “best of the tasting” by the Wall Street Journal. Modern Spirits uses only natural ingredients and small-batch production techniques to handcraft its vodka. Today, the company’s portfolio of spirits can be found in a growing number of fine restaurants and gourmet stores nationwide.

Early in 2008 Modern Spirits realized a long held wish to create a product which would increase the awareness of and give something back to the environment. TRU was launched as the first organic spirits line made from American wheat. Organic however is only part of the holistic approach taken. The packaging includes glass weighing 25% less than the average spirits bottle. Boxes made from at least 35% post consumer cardboard folded together to remove the need for tape and have built-in displays. Labels are made from tree free paper with soy based inks and recyclable corks and capsules.

As an added incentive to do more for the environment, Modern Spirits plants a tree for every bottle of TRU sold, and for some enthusiastic clients, for every TRU cocktail sold. Through Maine-based Sustainable Harvest, Modern Spirits has already helped plant approximately 50,000 trees in the American rainforests. The goal in creating TRU was not merely to offset Modern Spirits’ own carbon footprint, but to create a product that would build awareness of environmental issues and the efforts that everyone should be making to address them. With the tree planting program, Modern Spirits attempts to offset its carbon in a very proactive manner by involving their consumers and the community.

In August 2008, Modern Spirits commissioned Four Elements Consulting, LLC to perform a carbon footprint (C-footprint) analysis of its TRU organic line of spirits. A C-footprint analysis is the quantification of the greenhouse gases (GHGs) associated with the full life of a product or process. Armed with the C-footprint of its product, Modern Spirits will be able to assign the appropriate number of carbon offsets to the product so that it can be purchased or offered as “climate neutral,” which implies that the GHG emissions associated with the product have been offset. The analysis is calculated on 750 milliliters (ml) of TRU spirits, so that the carbon offset may be calculated based on one bottle of beverage.

The goal of the C-footprint analysis is to provide an accurate carbon footprint of Modern Spirits’ TRU organic line of spirits. The results may be used as follows:

- To provide data that will allow Modern Spirits to quantify and reduce or offset its GHGs associated with its products;
- To educate Modern Spirits’ customers and potentially assist in purchasing decisions
- To enhance Modern Spirits’ sustainability and environmental reporting with GHG-certified products;
- To potentially assist Modern Spirits’ in business decisions.

Modern Spirits is already offsetting carbon production via its tree planting program. This analysis does not account for the carbon offsets due to the tree planting program.

## II RESULTS: CARBON FOOTPRINT OF TRU ORGANIC SPIRITS

Based on the methodology, assumptions and modeling described in this report, the life cycle GHG emissions, in kilograms (kg) of carbon dioxide equivalents (CO<sub>2</sub>-eq) associated with one 750 ml bottle are found in Table 1.

**Table 1 TRU Spirits Total Life Cycle GHG Emissions per 750-ml Bottle**

	Total GHG (kg CO <sub>2</sub> -eq)
1 750-ml Bottle TRU Spirits	1.04

When looking at this overall number, it is difficult to interpret where in the life cycle the GHGs most contribute, so a contribution analysis is performed in order to understand the source of the impacts. Table 2 presents the breakdown of each life cycle stage as it contributes to the overall total.

**Table 2 TRU Spirits Life Cycle GHGs, kg CO<sub>2</sub>-eq per 1 750-ml Bottle**

Total (kg CO <sub>2</sub> -eq) per bottle	Production		Manufacturing		Distribution		Storage
	Bill of Materials	Packaging Materials	Energy	Ancillary Materials	Shipping - Truck	Shipping Materials	
1.04	10%	41%	4%	1.8%	29%	5%	9%

Production of materials in the product represents over 50% of the footprint, with most of that from production of packaging materials (e.g., the glass bottle). Distribution by truck amounts to nearly 30% of the total footprint, and product storage at a warehouse makes up less than 10%. Manufacturing energy makes up only 4% and materials used for shipping the product make up 5%. The modeling, assumptions, and explanations of the categories in the tables are described later in this report.

## III METHODOLOGY AND STANDARDS

This C-footprint analysis adheres to the ISO standards on Life Cycle Analysis, i.e., ISO 14040<sup>1</sup> and ISO 14044,<sup>2</sup> since performing a carbon footprint is based largely on the principles of performing LCA. LCA is a tool for the systematic evaluation of the environmental impacts of a product through all stages of its life, which include extraction of raw materials, manufacturing, transport and use of products, and end-of-life management (e.g., recycling, reuse, and/or disposal). Some guidelines on supply chain and life cycle GHG accounting exist but are in their infancy. Nonetheless, the study will also follow some of the current carbon footprint methodologies, including:

- CarbonFund.org CarbonFree(R) Product Certification Carbon Footprint Protocol; and
- Carbon Footprint Measurement methodology developed by Carbon Trust, which bases some of its methodology on ISO's LCA standards.<sup>3</sup>

WRI and WBCSD have started to move forward with the initiation of new guidelines on supply chain and lifecycle GHG accounting and reporting, but this is not available at this time. So while life cycle GHG accounting and reporting is still in their infancy, utilizing the above-mentioned sources will ensure sound C-footprint analyses based on the best available methodologies at the time of the study.

In producing the C-footprint analysis, Modern Spirits has strived to meet the five GHG Protocol principals on accounting and reporting as found in the guidelines and requirements of the International Organization for

<sup>1</sup> ISO 14040:1997(E), the International Standard of the International Standardization Organization, Environmental management. Life cycle assessment. Principles and framework.

<sup>2</sup> ISO 14044:2006, Environmental management – Life cycle assessment – Requirements and guidelines.

<sup>3</sup> Carbon trust, *Carbon Footprint Measurement Methodology*, version 1.3, March 2007. Found at: [http://www.carbon-label.co.uk/pdf/methodology\\_full.pdf](http://www.carbon-label.co.uk/pdf/methodology_full.pdf)

Standardization (ISO) 14064-1 Standard<sup>4</sup> and the World Business Council on Sustainable Development (WBCSD) / World Resources Institute (WRI) Greenhouse Gas Protocol for corporate accounting and reporting, hereinafter referred to as the “GHG Protocol”<sup>5</sup>, as follows:

1. **Relevance.** This C-footprint analysis reflects the product life cycle GHG emissions for Modern Spirits’ chosen inventory boundaries and will provide the information needed to meet Modern Spirits’ C-footprint goals and objectives.
2. **Completeness.** To the best of its ability, Modern Spirits has identified, accounted for and reported on all GHG emission sources and activities within the described life cycle boundaries. Any exclusions have been disclosed and justified.
3. **Consistency.** Modern Spirits has produced the results using methodologies that will enable consistent calculations for future C-footprint analyses and meaningful benchmarking of products over time, if necessary.
4. **Transparency.** To the best of its ability, Modern Spirits has produced its C-footprint analysis in a factual and coherent manner. It has stated and disclosed relevant assumptions, and provides references to the accounting and calculation methodologies and data sources used.
5. **Accuracy.** To the best of its ability, Modern Spirits has reduced uncertainties as far as practicable for LCA. Please see the limitations section for more information.

## IV LIFE CYCLE OF THE TRU ORGANIC LINE – SCOPE DEFINITION

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### PRODUCTS DEFINED

TRU spirits includes four products:<sup>6</sup>

- TRU Straight: clean, smooth and well-rounded with a neutral finish
- TRU Lemon: crisp, vivid and true to the flavor of ripe citrus
- TRU Vanilla: sweet, floral aroma with hazelnut tones and a lingering finish
- TRU 2 Gin: full bodied with bold flavors and lots of complexity

TRU spirits are made from 100% organic wheat distillate and distilled water. The infusions of lemon, vanilla and the 14 aromatics of the gin occur in the most natural manner possible – maceration. Real hand-zested organic lemon rind, real organic vanilla beans and real organic herbs and spices. This method creates full, bold flavors that include the whole of the ingredient, rather than just a single extract, oil or distillate.

These products differ only in their type and proportion of ingredients; they share the same production operations (e.g., product blending, tank cleaning and sanitizing), bottling operations, packaging (bottle type, weight, labels), and shipping operations. Since this analysis is an average of the product line, the raw material data has been averaged on a weighted basis; this is described in more detail later in the report.

The remaining life cycle stages have been modeled as identical for all products. Data used in this analysis is based on current (e.g., 2008) production. Since this is an average product, the reader should understand that impacts for actual distribution may vary depending on geographical location and shipping distances, and that the product line accounts for the ingredient formulas for a combination of four different products, not just one.

### SYSTEM BOUNDARIES - LIFE CYCLE STAGES DEFINED

LCA is a tool used to comprehensively quantify and interpret the environmental inflows and outflows of a product or process system, and the system boundary for the product or process encompasses its entire life

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<sup>4</sup> ISO 14064-1 Greenhouse Gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals.

<sup>5</sup> World Business Council on Sustainable Development (WBCSD) / World Resources Institute (WRI), **Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard** (Revised edition), found at <http://www.ghgprotocol.org>.

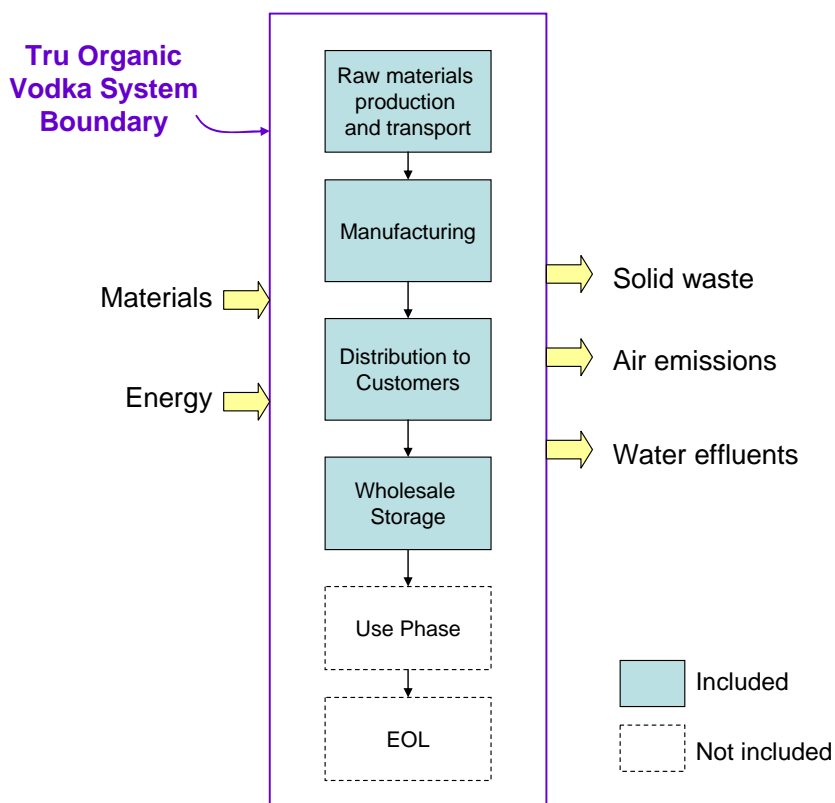
<sup>6</sup> More information can be found at <http://www.truvodka.com/>.

cycle. This C-footprint analysis includes four main life cycle stages of the product, described below and shown in the figure.

- **Raw materials and transportation.** Examples of production inputs include ethanol, distilled water, vanilla, dried herbs, and packaging materials; Transport of the materials to the Modern Spirits facility is also included.
- **Manufacturing.** Manufacturing includes blending and bottling the products.
- **Distribution.** Distribution includes transporting products from the Modern Spirits facility to the customer.
- **Storage.** Storage includes storage at a wholesale distribution warehouse.

Use of the product, i.e., drinking and enjoying the beverage, is not included in this analysis. Nor is end-of-life; it is assumed that the consumer sends the empty bottle to recycling, and this extra step need not be included in a product C-footprint. Note: one could argue that some consumers would not utilize recycling programs and would dispose of the bottle in the municipal solid waste (MSW) stream. However, more environmentally-conscious consumers who would purchase this organic product are more likely to take advantage of recycling programs.

**Figure 1 TRU Spirits System Boundaries**



### ORGANIZATIONAL AND OPERATIONAL BOUNDARIES

For manufacturing operations, Modern Spirits chose to include emissions within the boundaries for which it has direct operational control, and has the ability to influence, set policies and control energy use and operations. The products studied in this analysis are all produced at the Modern Spirits facility, located in Monrovia, California.

Modern Spirits is including scope 1 (direct facility emissions), scope 2 (indirect facility emissions), and scope 3 (i.e., other indirect emissions, which are a consequence of the activities of a company) emissions associated with the life cycle of TRU spirits. Operational boundaries are described below.

### Monrovia, California facility Scope 1 and Scope 2 Emissions

Modern Spirits' direct emissions include a propane forklift used to unload and move packaging and other materials at the plant and a company-owned car used for occasional local deliveries. Modern Spirits' indirect emissions come from electrical energy used for processing and cooling the plant. There are no emissions associated with physical or chemical processing. All of these scope 1 and scope 2 emissions are included in the manufacturing stage.

### Inclusion of Other Sources of GHGs: Scope 3 Emissions

This C-footprint analysis accounts for scope 3 emissions upstream and downstream of the Modern Spirits operations. Other sources of GHG emissions in this analysis include:

- The upstream production of the raw materials that make up the beverages and packaging;
- Transportation GHG impacts of those raw materials to Monrovia;
- Distribution of the final products to the customer; and
- Storage of the product.

### Exclusion of Other Sources of GHGs

Some scope 3 GHGs are not included in this C-footprint analysis, as not all scope 3 emissions need to be reported. Some excluded GHGs come from human activities, including employee travel (business travel, commuting). Additionally, impacts for facility construction and capital equipment are also excluded, as these impacts typically are negligible when allocated over the total quantity of product manufactured over the life cycle of facilities and equipment. Retail store impacts (heating, cooling, etc.) are not included, nor is transport of customers to and from the store.

## **FUNCTIONAL UNIT**

An LCA system is always defined by the function or service of the product it describes, so that results may be understood in relation to that function. A functional unit is defined so that products can be calculated on some quantitative basis. The function of Modern Spirits' TRU spirits is to *provide an enjoyable alcoholic beverage to responsible consumers over the age of 21 years*. The functional unit of the product has been defined as *one 750-ml bottle of TRU spirits sold to a responsible consumer over the age of 21 years*.

## **CUT-OFF CRITERIA**

ISO 14044 requires a cut-off criterion to be defined for the selection of materials and processes to be included in the system boundary. Several criteria are used in LCA practice to decide which inputs are to be studied, including mass, energy and environmental relevance.<sup>7</sup> The mass criterion was applied, and a cut-off goal of 99% of material inputs was defined, a much more aggressive goal than the Carbon Trust methodology, which calls for inclusion of at least 90% of the mass of final product. Detailed information on the materials comprising the life of the product was collected, and every effort was made to include life cycle data for the production of these materials or to find suitable surrogate data (i.e., if data on that material was not available). A discussion as to the meeting of the cut-off criteria is found in the data quality section.

## **V CALCULATION METHODOLOGY AND TOOLS**

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### **CALCULATION APPROACH FOR MODERN SPIRITS' C-FOOTPRINT ANALYSIS**

#### **ALL LIFE CYCLE STAGES EXCEPT MANUFACTURING**

For all life cycle stages except manufacturing, the GHG emissions were calculated using a commercial LCA software tool, SimaPro 7.0.<sup>8</sup> SimaPro contains U.S. and European databases on a wide variety of materials in addition to an assortment of European- and U.S.-developed impact assessment methodologies, including the Intercontinental Panel on Climate Change (IPCC) 2007 factors, which were used for this assessment (see Appendix A).

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<sup>7</sup> ISO 14044, Section 4.2.3.3.

<sup>8</sup> PRé Consultants: *SimaPro 7.0 LCA Software*. 2006. The Netherlands.

## MANUFACTURING LIFE CYCLE STAGE

Modern Spirits used the following GHG inventory calculation tools to calculate the GHG emissions from its direct operations:

- WBCSD/WRI worksheet tool and accompanying guidance document: *Indirect CO2 Emissions from the Consumption of Purchased Electricity, Heat, or Steam*,<sup>9</sup> which estimates CO2 emissions from the electricity purchased by Modern Spirits for its facility operations; and
- WBCSD/WRI worksheet tool: *CO2 Emissions from Transport or Mobile Sources*,<sup>10</sup> which measures direct CO2 emissions from the mobile sources used by Modern Spirits.

This C-footprint analysis utilized the default emissions factors and calculation tools that accompany the GHG Protocol.

## GWP WEIGHTING FACTORS AND GHG INVENTORY CALCULATIONS

All of the GHGs in this C-footprint analysis have been normalized on a 100-year time horizon CO2-eq. basis. The life cycle inventory (LCI) output of GHGs from SimaPro are multiplied by their respective weighting factors to come up with a total GHG in CO2-eqs. The list of possible GHGs and their weighting factors are found in Appendix A.<sup>11</sup> A sample calculation converting inventory results to the total GHG is provided in Table 3.

**Table 3: Sample Calculation**

Selected GWP Flows	Weighting Factor	Sample LCI Result	Calculated GHG Result
Carbon Dioxide	1	2000	2000
Methane	21	15	315
Nitrous Oxide	310	0.04	12.4
<b>Total GHGs in CO2-equivalents →</b>			<b>2327.4</b>

## VI CARBON FOOTPRINT ANALYSIS – MODELING AND ASSUMPTIONS

### DATA COLLECTION

A detailed questionnaire was developed to collect process data from Modern Spirits' facility, and included raw material inputs, process energy use, solid wastes, releases to air and water, and total product output. Data were collected for the most recent time period in order to reflect current production practices and the product. In addition to the facility questionnaire, supplemental information was gathered for the life cycle stages following production, including distribution to customers and packaging.

### LIFE CYCLE STAGE MODELING AND ASSUMPTIONS

#### UPSTREAM MATERIALS PRODUCTION

##### Raw Materials and Packaging

**Data Tables.** Table 4 through Table 7 provide the bill of materials (BOM) for each product in the TRU spirits line, and Table 8 provides packaging data, which is identical for each product.

**Table 4 Contents of TRU Straight Vodka**

Ingredients	Per 350 gal
Ethanol (wheat-based), 95%	...
Water	...

<sup>9</sup> Documents entitled, < ElectricityHeatSteamPurchase\_tool1.2.xls> (version stated within the document: Version 1.2, January 2007) and <ElectricityHeatSteamPurchase\_guidance1.2.pdf> Downloaded from <http://www.ghgprotocol.org>.

<sup>10</sup> Documents entitled, <co2-mobile.xls> (version stated within the document: Version 1.3, January 2005) and <co2-mobile.pdf>. Downloaded from <http://www.ghgprotocol.org>.

<sup>11</sup> Note: The LCI results from SimaPro may or may not include all the flows on this list.

**Table 5 Content of TRU Lemon Vodka**

Ingredients	Per 350 gal
Ethanol (wheat-based), 95%	...
Water	...
Lemon	...

**Table 6 Content of TRU Vanilla Vodka**

Ingredients	Per 350 gal
Ethanol (wheat-based), 95%	...
Water	...
Vanilla bean	...

**Table 7 Content of TRU 2 Gin**

Ingredients	Per 20 liters
Ethanol (wheat-based), 95%	...
Water	...
Lemons	...
Vanilla bean	...
Juniper berries	...
Other dried herbs	...

**Table 8 Product Packaging**

Material	Quantity per 750 ml product	Comments
Glass bottle	620 g	
T-top synthetic cork no.7 recyclable	8 g	Assume resin-based material
Paper label	2 g	1000-label roll = 2kg (roll included paper label peels off and center board)
PETG Shrink capsule	0 g	goes over the top of the cork - this is considered negligible, especially since it did not register a weight

**Data Sources.** The modeling of these materials comes from the U.S. LCI database, which is the most accepted set of U.S.-based LCI data on fuels, energy, and transportation,<sup>12</sup> the EcoInvent database,<sup>13</sup> and the SimaPro database. Where these sources of data did not contain information on certain materials used, a public search was made for alternative sources of LCI data on the materials, or else surrogate data was used. The Data Quality section provides more detailed information on the data in this study.

The carbon uptake to produce the biobased products (e.g., the wheat, lemons, etc.) has been included in the model, and as will be described later on, the release of that carbon back into the atmosphere is also accounted for. Also, there is some product loss during manufacturing, calculated to approximately 3%. This product loss has been accounted for in the model.

#### Transportation of Materials to the Modern Spirits Facility

Transportation of each of these materials by truck and car to Modern Spirits was modeled as part of the upstream production stage.

<sup>12</sup> Found at: <http://www.nrel.gov/lci/>.

<sup>13</sup> Generally reputed to be current, representative data on processes and chemicals, the EcoInvent database is a for-purchase database developed by the Swiss Center for Life Cycle Inventories. EcoInvent is used in conjunction with other databases in the SimaPro software. More information can be found at [www.ecoinvent.org](http://www.ecoinvent.org).

### Averaging the Production Stage

As noted before, the product line average was made on a weighted average basis, based on current and potential sales. According to Modern Spirits, since its launch in April, Straight vodka accounted for xx% of sales, Vanilla xx% and Lemon xx%. Gin has not come on the market yet, but in taste tests it has been received well so far. The weighted average was calculated on the following basis:

- Straight: ■ ■ %
- Lemon: ■ ■ %
- Vanilla: ■ ■ %
- Gin: ■ ■ %

## **MANUFACTURING**

### Energy Usage

Manufacturing data includes the following:

**Propane forklift.** Propane is used to haul materials at the plant. Even though Modern Spirits borrows this forklift, it is still accounting for the GHG emissions generated from its use. Total usage has been estimated by Modern Spirits as approximately 10-12 hours per year. With a 33-lb propane tank providing approximately 8 hours of use, their total propane consumption is 49.5 lbs per year.

**Gasoline-powered vehicle.** Their gasoline-powered company-owned car is used for occasional local deliveries and errands, and Modern Spirits estimates this usage to be approximately 10 miles per week (averaging zero miles for some weeks and a once-monthly delivery to Santa Monica or Beverly Hills at 20 miles each way). 10 miles per week equates to 520 miles per year. At 20 miles to a gallon, this amounts to 26 gallons of gasoline per year.

**Electricity.** Electricity is used for:

- Pumping alcohol for blending;
- Bottling machine;
- Air conditioner;
- Labeling machine; and
- Capsule shrinking machine.

Electricity data was collected from utility bills for the period of January through June 2008, and amounts to 4313 kWh. During that 6-month time period, XXX bottles of spirits were produced. Therefore, electricity usage per bottle equated to 0.13 kWh per bottle.

Using the half-year production of XXX and multiplying by 2, the yearly propane and gasoline quantities could be normalized on a per-bottle basis. Table 9 summarizes the total energy use for each energy source and the associated quantity per bottle. As noted above, these have been modeled in the GHG Protocol Excel tools.

**Table 9 Energy use and production – all products**

<b>Energy Source</b>	<b>Quantity</b>	<b>Usage per Bottle</b>
Electricity (kWh)	4313	0.13
Propane (lbs)	49.5	0.0008
Gasoline in a car (gal)	26	0.0004

### Other Manufacturing Impacts

**Ancillary materials for cleaning.** Each 350-gallon batch of spirits produced involves cleaning a tote twice. This would equate to 1 cup each of citric acid and chlorinated trisodium phosphate. Additionally, the following are used:

- one cup of dishwashing detergent to clean the stainless bowls, stirring paddles etc,
- one cup of clothes detergent to clean the infusion bags and dish cloths, and
- one cup of environmentally-friendly detergent (Simple Green) to mop the floors.

These materials were included in the manufacturing stage of the model, and were modeled on a per bottle basis. Data sets for these materials came from the EcolInvent and SimaPro databases.

**Air Emissions.** No GHGs besides fuel combustion-related emissions are released from this facility.

**Recovered material.** A total of 15% of the used lemons are given away to family and friends, and this reuse of materials is not included in the model.

**Waste.** Many of the ingredients listed in Table 5, Table 6, and Table 7 are added only for their flavor. So essentially, after their essence is added to the ethanol and water, they are disposed of. This model takes into account the disposal and GHG-related emissions of the portion of lemons (not reused), vanilla, juniper berries, and other herbs. First, their usage per bottle, per weighted average of each product, was calculated. Then a carbon-equivalent emissions factor from an EPA study on GHGs from landfills was applied,<sup>14</sup> as follows.

Total weighted average biomass discarded per 750-ml bottle	0.029 kg, or 2.9 E-5 metric ton (MT)
Food discards total emission factor from an average U.S. landfill	0.209 metric ton carbon-eq. (MTCE)
Total C-eq. per 750-ml bottle	5.9 E-6 MTCE
<b>Total CO<sub>2</sub>-eq. per 750-ml bottle</b>	<b>2.2 E-5 MT, or 0.022 kg</b>

The EPA study took into account:

- Net GHG emissions from methane generation from food discards in the landfill;
- Carbon storage from the food discards; and
- Transportation CO<sub>2</sub> emissions from transport of the material to the landfill.

Additionally, the U.S. average landfill accounts for the average of emissions from: landfills without any landfill gas (LFG) recovery, landfills with LFG recovery and flaring, and landfills with LFG recovery and production of electricity with the LFG. The “food discards” category was used as these ingredients fit best into that category in this study.

## DISTRIBUTION TO CUSTOMERS

### Shipping Information

The shipping distance to customers was estimated based on Modern Spirits' general sales information. Since over half of their sales stay on the west coast and less than half is distributed to the eastern U.S., the average estimated distance came to 1500 miles. The product is shipped by truck.

### Shipping Materials

Shipping materials include the following:

**Table 10 Product Shipping Materials**

Material	Quantity per 750 ml product	Comments
Shipping box	314 g	at least 35% recycled. Note that for small shipments (3% of total), the shipment is double-boxed. This is accounted for.
Stretch wrap around pallets	0.034 m <sup>2</sup>	20 m <sup>2</sup> /pallet (576 btl) Polyethylene
Corner guards used for small shipments (3% of total)	114 g	100% recycled paper/cardboard - free of upstream production burden
Filling material used for small shipments (3% of total)	Not quantified	They use their own waste paper/cardboard. Since this is a reused material, it is free of upstream production burden

<sup>14</sup> Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks, Chapter 6, Exhibit 6-6, found at: <http://epa.gov/climatechange/wycd/waste/downloads/chapter6.pdf>

## STORAGE

Modern Spirits rents storage space in New Jersey for a small portion of their production. For example, in the past year, XX pallets (XXX bottles) were stored at this facility. Storage based on box volume was accounted for: at 6 bottles per box, with one box approximately 0.5 cubic feet, the total stored space equated to 240 cubic feet. The dataset from Ecolnvent on Wholesale Warehouse (+20 degrees C) was used, which accounted for these temperature-controlled conditions.

## VII DATA QUALITY REQUIREMENTS AND EVALUATION

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This study adheres to the ISO standards on data quality to help ensure consistency, reliability, and clear-cut evaluation of the results. The following sections describe the study's data quality in accordance with ISO 14044.<sup>15</sup>

### REPRESENTATIVENESS

Representativeness includes the following:

- Time/temporal coverage – describes the age of data and the minimum length of time (e.g., one year) over which data are collected;
- Geographical coverage – describes the geographical area from which data for unit processes are collected to satisfy the goal of the study; and
- Technological coverage (or the technology mix) – describes the technology mix of the data sets, which may include weighted average of the actual process mix, best available technology, or worst operating unit.

Detailed and current information on Modern Spirits' materials, energy and fuel use at manufacturing, distribution, and other life cycle aspects of the TRU product line were provided. The data are based on Modern Spirits' technologies and practices, and the data sets are for the most part based on U.S. data\*. Therefore, this line of spirits can be considered representative.

**\*Note on geographical coverage of the data sets:** In LCA it is quite common to use a mix of data sets from different geographical locations, for several reasons. First, data for all materials is not always available for all geographies. Also, available data from a preferred geographical location may be very poor in quality (may be outdated, based on faulty emissions factors, based on old or non-representative technologies, based on one plant or a representative sample, etc.). Finally, an alternative geography or data set may be used because it is better than no data at all. In order to minimize an LCA's margin of error associated with data based on a different geographical location, it is Four Elements' practice to customize the data sets to the preferred geographical location.

### CONSISTENCY

Consistency is a qualitative understanding of how uniformly the study methodology is applied to the various components of the study. Consistency was maintained in the handling of the various aspects of this study. A single person at Modern Spirits provided and reviewed the data for the study. The consultant performed the data analysis and aggregation in a consistent manner with other LCA or carbon footprint analyses. One area that may not be considered particularly consistent was the use of the GHG protocol tool instead of the LCA software for manufacturing. However, this was done in order to be consistent with corporate GHG inventory data – something that will be very useful should Modern Spirits ever decide to perform a full corporate GHG inventory.

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<sup>15</sup> ISO 14044 Section 4.2.3.6

## REPRODUCIBILITY

The level of detail and transparency provided in this report allow the results of this study to be reproduced by another practitioner.

## PRECISION

Precision represents the degree of variability of the data values for each data category. The raw materials for the product line were based on actual quantities in the products, so there was not any variability in the data. The manufacturing data was very precise and there was not any variability in the data.

## COMPLETENESS

ISO 14044 section 4.2.3.6 defines completeness as the “percentage of flow that is measured or estimated.”<sup>16</sup> This study can be considered complete since most, if not all data provided was based on measured or estimated data. In terms of inclusion of production data of the raw materials, the cut-off criteria of 99% was exceeded. Some of the data for the ingredients in the Gin were not included due to lack of available production data. This amounted to 2.8% of the total mass of gin inputs (excluding water), yet 0.3% of the total product line since gin accounts for 10% of the product line.

## SOURCES OF DATA

Both primary and secondary data are used in modeling the spirits. Primary data (collected directly from Modern Spirits) are the preferred, highest quality data for life cycle modeling. Primary data were gathered for the manufacture of the product and Modern Spirits provided data pertaining to other aspects of the product. With regards to secondary data, from a practical standpoint it is impossible to collect actual process data for each of the thousands of unit processes included in a complete life cycle model so the use of secondary data in an LCI is normal and necessary. Secondary data is applied to production of material inputs, production and combustion of fuels used for process energy, and transportation energy throughout the life cycle. This study used the best data that was available.

## LIMITATIONS AND UNCERTAINTY

Because the quality of secondary data is not as good as primary data, the use of secondary data becomes an inherent limitation to the study. Secondary data may cover a broad range of technologies, time periods, and geographical locations. Because hundreds of data sets are linked together and because it is often unknown how much the secondary data used deviate from the specific system being studied, quantifying data uncertainty for the complete system becomes very challenging. As a result, it is not possible to provide a reliable quantified assessment of overall data uncertainty for the study.

## VIII APPENDIX

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Appendix A: GHG weighting factors used for the calculations in this C-footprint analysis

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<sup>16</sup> ISO 14044:2007, Section 4.2.3.6.

## APPENDIX A

Table 11 Weighting factors used for the Calculations in this Life Cycle GHG Inventory<sup>17</sup>

Greenhouse gas	kg CO2 eq
Butane, 1,1,1,3,3-pentafluoro-, HFC-365mfc	794
Butane, nonafluoroethoxy, HFE-569sf2	59
Butane, nonafluoromethoxy, HFE-7100	297
Butane, perfluoro-	8860
Butane, perfluorocyclo-, PFC-318	10300
Carbon dioxide, biogenic	-1
Carbon dioxide, fossil	1
Chloroform	756
Dimethyl ether	1
Dinitrogen monoxide	310
Ethane, 1-chloro-1,1-difluoro-, HCFC-142b	2310
Ethane, 1-chloro-2,2,2-trifluoro-(difluoromethoxy)-, HCFE-235da2	350
Ethane, 1,1-dichloro-1-fluoro-, HCFC-141b	725
Ethane, 1,1,1-difluoro-, HFC-152a	124
Ethane, 1,1,1-trichloro-, HCFC-140	146
Ethane, 1,1,1-trifluoro-, HFC-143a	4470
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1430
Ethane, 1,1,2-trichloro-1,2,2-trifluoro-, CFC-113	6130
Ethane, 1,1,2,2-tetrafluoro-, HFC-134	1430
Ethane, 1,1,2,2-tetrafluoromethoxy-, HFE245cb2	708
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	10000
Ethane, 2-chloro-1,1,1,2-tetrafluoro-, HCFC-124	609
Ethane, 2,2-dichloro-1,1,1-trifluoro-, HCFC-123	77
Ethane, 2,2,2-trifluoromethoxy-, HFE245fa2	659
Ethane, chloropentafluoro-, CFC-115	7370
Ethane, hexafluoro-, HFC-116	12200
Ethane, pentafluoro-, HFC-125	3500
Ether, 1,1,2,2-Tetrafluoroethyl 2,2,2-trifluoroethyl-, HFE-347mcf2	575
Ether, 1,1,2,2-Tetrafluoroethyl methyl-, HFE-254cb2	359
Hexane, perfluoro-	9300
HFE-236ca12 (HG-10)	2800
HFE-338pcc13 (HG-01)	1500
HFE-347pcf2	580
HFE-43-10pccc124 (H-Galden1040x)	1870
Methane	21
Methane, biogenic	21
Methane, bromo-, Halon 1001	5
Methane, bromochlorodifluoro-, Halon 1211	1890
Methane, bromotrifluoro-, Halon 1301	7140
Methane, chlorodifluoro-, HCFC-22	1810
Methane, chlorotrifluoro-, CFC-13	14400
Methane, dichloro-, HCC-30	8.7
Methane, dichlorodifluoro-, CFC-12	10900
Methane, difluoro-, HFC-32	675
Methane, fossil	21
Methane, monochloro-, R-40	13
Methane, pentafluoromethoxy-, HFE-134	6320
Methane, tetrachloro-, CFC-10	1400
Methane, tetrafluoro-, CFC-14	7390
Methane, trichlorofluoro-, CFC-11	4750
Methane, trifluoro-(difluoromethoxy)-, HFE-125	14900
Methane, trifluoro-, HFC-23	14800
Methane, trifluoro-methoxy-, HFE-143a	756
Nitrogen fluoride	17200
Pentane, 2,3-dihydroperfluoro-, HFC-4310mee	1640
Pentane, perfluoro-	9160
PFC-9-1-18	7500
PFPPIE	10300
Propane, 1,1,1,2,3,3,3-heptafluoro-, HFC-227ea	3220
Propane, 1,1,1,3,3,3-hexafluoro-, HCFC-236fa	9810
Propane, 1,1,2,2,3,3, hexafluoromethoxy- HFE-356pcc3	110
Propane, 1,1,3,3-tetrafluoro-, HFC-245fa	1030
Propane, 1,3-dichloro-1,1,2,2,3-pentafluoro-, HCFC-225cb	595
Propane, 3,3-dichloro-1,1,1,2,2-pentafluoro-, HCFC-225ca	122
Propane, perfluoro-	8830
Sulfur hexafluoride	22800
Sulphur, trifluoromethyl pentafluoride	17700

<sup>17</sup> The weighting factors for CO<sub>2</sub>, N<sub>2</sub>O, and CH<sub>4</sub> come from < StationaryCombustion v4.xls>. All other weighting factors come from SimaPro IPCC LCIA method, based on the IPCC Fourth Assessment Report: *Working Group I Report "The Physical Science Basis"*, found at: <http://www.ipcc.ch/ipccreports/ar4-wg1.htm>.