*Clean*Metrics™

FoodCarbonScope™

Product Technical Brief

CleanMetrics Corp.
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Contents

What is FoodCarbonScope?

FoodCarbonScope™ is a web-based software tool for the modeling and analysis of life cycle greenhouse gas (GHG) emissions, energy use and water use in food and beverage products.

Key benefits of FoodCarbonScope™:

- Provides an interactive, easy-to-use platform for analyzing complex product supply chains.
- Comprehensive analysis, covering all life cycle stages from cradle to grave (agriculture, processing/packaging, distribution, retail, cooking, waste disposal, etc.) and accounting for all GHG emissions and resource use.
- Comes with the largest commercially available life cycle inventory (LCI) database for North American food production and processing.
- Delivers standards-compliant life cycle assessment (LCA) results at a fraction of the typical costs associated with conventional LCAs of food and beverages.
- Highly customizable to match the level of detail needed for the problem at hand.
- Targets the three environmental metrics that are most critical for businesses and consumers: GHG emissions, energy use and water use.

Who is it for?

FoodCarbonScope™ has been expertly designed from the ground up specifically for the food and beverage industry. Agriculture contributes 13.5% of global GHG emissions[1] and consumes 67% of the fresh water worldwide. With processing, refrigeration, packaging, transport and waste disposal added, it is easy to see that foods and beverages are a major consumer of resources as well as a significant source of national and global GHG emissions, not to mention personal environmental footprints. Foods and beverages must therefore be at the core of any meaningful strategy for conserving resources and mitigating climate change. Squeezing out waste and inefficiency in the production, delivery and consumption of foods and beverages makes both economic and environmental sense.

FoodCarbonScope™ can enable this by providing deep insights into product life cycles, allowing food producers, distributors and retailers to incorporate environmental considerations more easily into their business decisions. FoodCarbonScope™ can also be a valuable tool for

[1] This figure excludes the impacts of land use changes.

environmental consultants, third-party product certifiers, and other organizations and researchers focused on food sustainability.

Applications

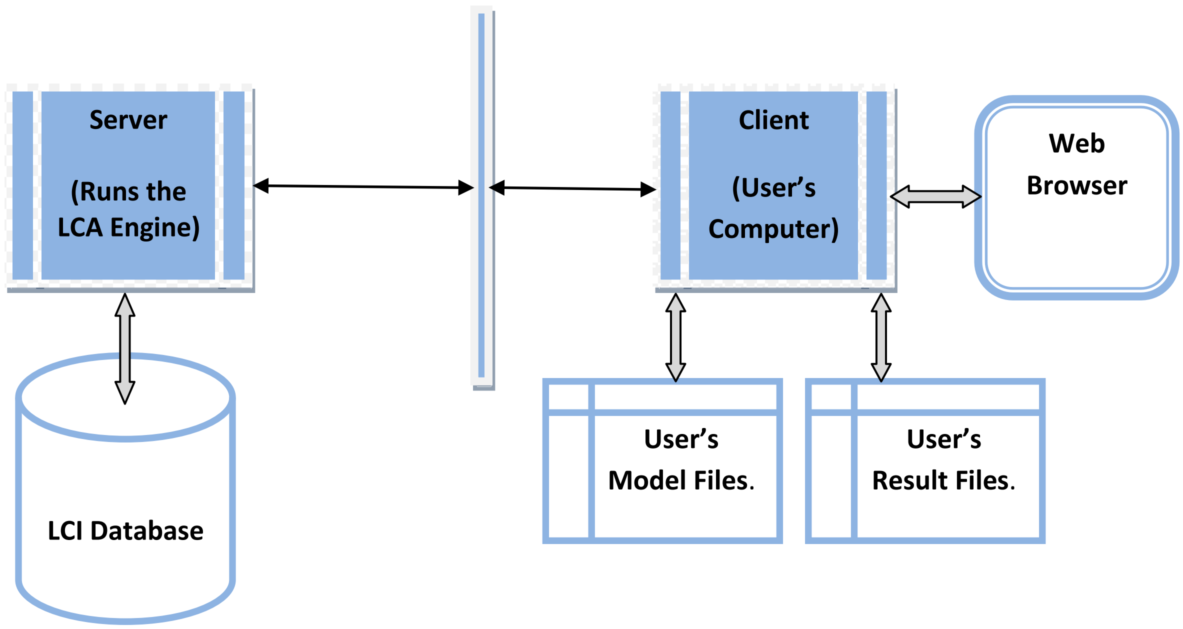
Analysis and results from FoodCarbonScope™ can be used in a variety of applications including:

- Product eco-labeling – including carbon and water footprint labels – and other business-to-business and business-to-consumer sustainability communications.
- Competitive environmental benchmarking of food and beverage products.
- Identification of environmental hotspots and other inefficiencies in supply chains.
- Comparative evaluation of alternative suppliers, logistics, packaging and processing.
- Analysis of “what-if” scenarios to evaluate the potential benefits of supply-chain modifications and optimizations.

How is FoodCarbonScope different from other tools?

FoodCarbonScope™ starts with the basic premise that software tools and data for product LCAs should be broadly accessible to professionals in every major industry. This is a key enabling factor not only for assessing the environmental impacts of products on the market today, but also to begin the serious task of significantly reducing the impacts of the next generation of products. To address this need, the FoodCarbonScope™ software has been architected based on a thorough understanding of the target industry. An intuitive web-based user interface allows users to input their production or operational data easily into the software, while giving them access to the full potential of LCA through a powerful analysis engine and a large LCI database under the hood.

FoodCarbonScope™ delivers standards-compliant life cycle assessment (LCA) results at a fraction of the typical costs associated with conventional LCAs of food products. It dramatically eases the difficulties in performing product LCAs without sacrificing accuracy or rigor. In the past, choices were limited to difficult-to-use LCA tools that require high levels of technical expertise and easy-to-use tools that can only be used for simplified/screening analyses. FoodCarbonScope™ is a breakthrough solution that bridges this gap. It combines an affordable and easy-to-use web interface with the rigorous and detailed analysis required for demanding applications such as product eco-labeling and optimizing environmental metrics.



Modeling and analysis features

FoodCarbonScope™ offers a complete set of modeling and analysis features needed to analyze both simple and complex product life cycles in the food and beverage industry.

- Detailed supply chain structures can be constructed using a simple point-and-click interface.
- GHG emissions, energy use and water use in agricultural production can be modeled comprehensively, including:
  - Contributions of all inputs such as fertilizers, pesticides, irrigation, electricity/fuel, and freight transport.
  - Non-energy GHG emissions at the farm level due to issues such as waste/manure management, crop residues, biological nitrogen fixation, nitrogen fertilizer use, enteric fermentation, flooding of rice fields, etc.
  - Carbon emissions from agricultural soils, and carbon sequestration in agricultural soils and biomass.
- Full accounting of food processing and cooking, choosing from a full range of commercial equipment and processes.
- Packaging materials and configurations – including both primary and secondary packaging – can be easily modeled for both raw food commodities and processed foods.

- Transport – including multi-modal domestic and international freight transport with/without refrigeration – and refrigerated storage of raw and processed food products can be readily included throughout the supply chain.
- Optionally, both domestic and international transport distance calculations can be automated by accessing the built-in mapping and routing module.
- Management of food and packaging waste – including options such as composting and landfilling in different climate zones, and energy recovery through methane capture and incineration – can be incorporated throughout the supply and consumption chain.
- An extensive LCI database provides comprehensive coverage of all aspects of food/beverage life cycles and allows for rapid development of accurate product life cycle models.
- Flexible modeling approach allows users to optionally input their own proprietary agricultural production and/or processing data to model specific farms, suppliers or processing facilities at various levels of detail.
- Detailed results are reported live on screen and saved to spreadsheets with full supporting documentation.
- All user data is private and stored on users' own hard disks.

Life cycle inventory database

FoodCarbonScope™ comes integrated with CarbonScopeData™, an LCI database containing cradle-to-gate and unit process data for over 1000 products and processes in the food and agriculture sectors covering a full range of crop and animal production systems, commercial food processing, commercial cooking appliances, packaging, and waste disposal. The majority of this data is for US and Canadian production and processing drawn from over a dozen major agricultural states/provinces, *making CarbonScopeData™ the largest commercially available LCI database for North American food production and processing*. In addition, the database includes food production data for Europe and other parts of the world.

Product/Process Category	Number of Distinct Product Systems or Processes in LCI Database[2]
Beans/Pulses	22
Dairy	30
Fibers	16

[2] Some of the processes – such as transport, refrigeration, waste management or manure management – use parameterized process models that rely on several input variables to perform the output calculations.

Fruits/Berries	122
Grains	73
Live Animals	26
Meat/Poultry	39
Miscellaneous[3]	15
Processed Foods [4]	68
Nitrogen-fixing Forages	9
Non-nitrogen-fixing Forages	7
Nuts/Seeds	19
Root Crops	20
Seafood	42
Tubers	18
Vegetables	61
Food Processing Methods	49
Commercial Cooking Appliances	139
Packaging Materials	52
Fuel Combustion	12
Electricity Grids[5]	70
Transport Modes	8
Refrigeration/Freezing	9
Solid Waste Disposal	108
Manure Management	19
Waste Water Treatment	22
Fertilizers	10
Pesticides	48
Other Agricultural Inputs	12

CarbonScopeData™ also includes LCI data for a full range of packaging materials, refrigerated storage, transport modes, fuels, and accurate electricity emission factors by grid region and country. The table above summarizes the contents of CarbonScopeData™ that are relevant to FoodCarbonScope™.

[3] Includes coffee beans, cocoa beans, sugarcane, etc.
[4] Includes a full spectrum of typical processed foods, such as: breads, cookies, cakes, pastries, pasta, breakfast cereal, potato products, margarine, sauces, ketchup, oils, flours, juices, wine, soymilk, tofu, peanut butter, sausage, pepperoni, ground coffee, cocoa products, corn syrup, sugar, etc.
[5] Includes 26 US grid regions, plus 44 national grids around the world.

Standards

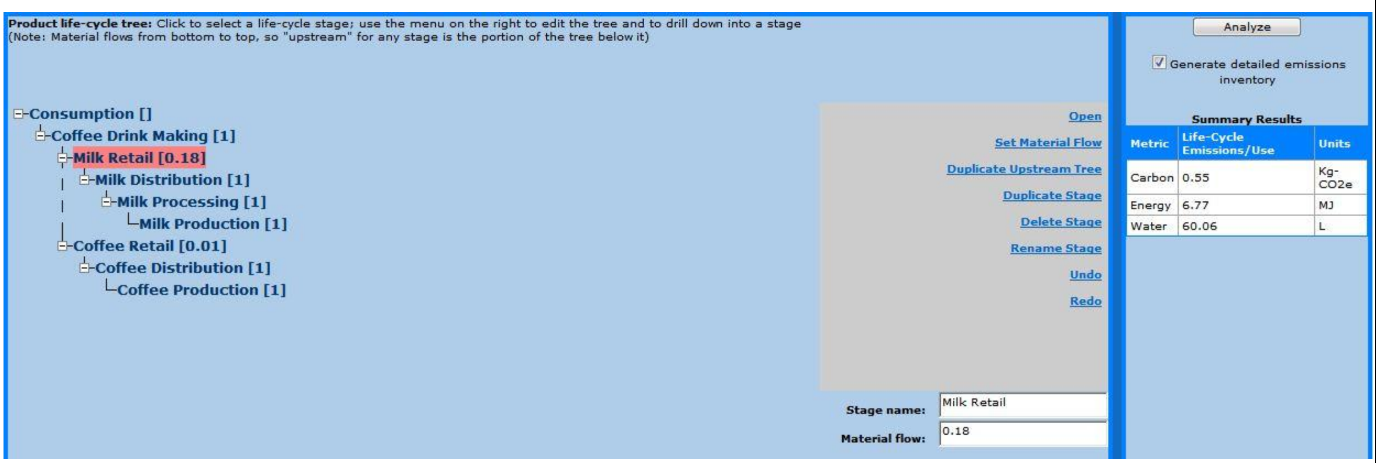
FoodCarbonScope™ can be used to generate results that are in compliance with current international standards (ISO 14040 series, PAS 2050, GHG Protocol) for life cycle assessment and product carbon footprint analysis, and with other major standards that are in development. Baseline GHG emissions from agricultural soils, manure management, enteric fermentation and waste disposal are calculated using the IPCC Guidelines for National GHG Inventories (tier 1 or tier 2), with more advanced modeling included in selected areas.

How does FoodCarbonScope work?

FoodCarbonScope™ provides a modeling framework based on key life cycle stages that can be combined as needed to model the full product life cycle. FoodCarbonScope™ classifies the life cycle stages of a food or beverage product into six basic types:

- Production
- Processing
- Distribution
- Retail
- Cooking
- Consumption

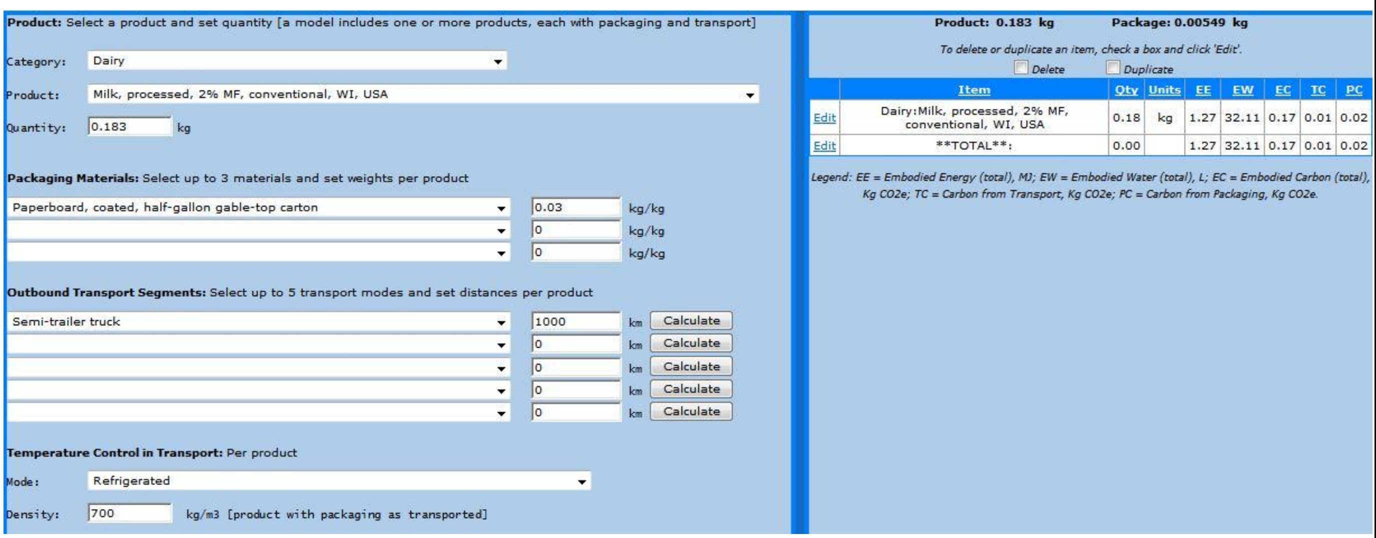
Life-cycle tree



A product life cycle model can include some or all of the stages, as well as more than one instance of a particular stage type, depending on the nature of the product and the system boundary[6] chosen by the user. FoodCarbonScope™ allows the user to build a product life cycle tree for the system being modeled using these basic stage types. The screenshot above shows an example of this for modeling the production of a coffee drink where two main ingredients (coffee and milk) are sourced through different supply chains and then combined to produce the final product. "Consumption" is the final stage in this model and all materials flow from the various production stages toward the final consumption stage.

Production model

After constructing the life cycle tree, each stage in the tree can be modeled in detail. The next screenshot below illustrates a production modeling page where the production of milk is being modeled. The user has the option of populating a production model with data for one or more of the nearly 600 agricultural products or processed foods available in the LCI database[7]. In each case, packaging and transport can be added to complete the model up to the input of the next stage in the life cycle tree. Refrigerated transport options are available for modeling perishable items such as dairy and meats.



[6] Such as cradle to grave, cradle to retail, or cradle to farmgate.
[7] The LCI database provides cradle-to-farmgate or cradle-to-gate data for production.

Custom production model

For advanced users, FoodCarbonScope™ provides a complete interface and calculation engine for developing custom models of agricultural production. Any of the standard agricultural products in the LCI database can be brought into the custom modeling page shown on the next page, where a detailed inventory of agricultural inputs can be examined along with soil conditions, tillage/management practices and any recent changes in land use. Custom agricultural products can then be created by modifying the underlying agricultural production data for any of the standard products. Alternately, users can model entirely new agricultural products by inputting their own detailed production data from external sources.

A full cradle-to-farmgate LCA can be performed instantly on the custom modeling page using the new or modified data, and then the results can be used in the larger life cycle product model being developed. The custom modeling feature can also be used to analyze and quantify the sensitivities of the various inputs and assumptions used to model any agricultural production system.

Model Name: Cherries, Sweet Cherries, conventional (micro-sprinkler irrig.), for fresh eating, CA, USA - CustomModified-4

Model Type: Crop Product

Crop Feed Tag:

Perennial/Tree Species: Deciduous Average

Tree Density: 132.66 trees/acre Tree Lifetime: 25 years

Crop/Animal Category:

Quantity: 3588.1911983 kg Allocation Factor: 0.99

Analysis Type: Steady-state

Comments: PRODUCTION: Conventional, micro-sprinkler irrigation ; San Joaquin Valley North, CA, USA ; 2005-2005. DATA SOURCE: Univ of Calif., Davis, Agricultural Cost and Return Studies (http://coststudies.ucdavis.edu/current.php).

Climate Zone: Warm Temperate Moisture Regime: Dry

Soil Type: LAC Soils Land Area: 1 acres

Prior Land Category: Cropland Current Land Category: Cropland

Prior Use/Forest Type: Perennial/Tree Crop Current Use/Forest Type: Perennial/Tree Crop

Prior Management: No Till Current Management: Full Till

Prior Input/Litter: Low Carbon Current Input/Litter: Medium Carbon

Current Year: 21 Transition Period: 20 years

Manure Management: Pasture/Range/Paddock Average Temperature: Cool (<= 14 C)

Input or Waste Output: Select an input/waste item and set quantity Save Item to Model Cancel Edit

Category: Fertilizers

Item: Nitrogen - synthetic, other than CN/CAN and Urea

Electric Grid:

Climate Zone: Waste Material:

Quantity: 44.90610541594 kg Wastewater Density: 0 kg/m3

Transport Segments (factory/farm gate to farm): Select up to 3 transport modes and set distances

Semi-trailer truck 1600 km Calculate

Single-unit truck 200 km Calculate

0 km Calculate

Cradle-to-Farmgate LCA Results: Analyze

To delete or duplicate an item, check a box and click 'Edit': Delete Duplicate

	Item	Qty	Units	EE	EW	EC	TC
Edit	Water:Water, agricultural, USA	3051938.8013	L	0.00	3051938.80	0.00	0.00
Edit	Energy:Gasoline, combusted in equipment	33.8305	L	1273.14	0.00	85.56	0.00
Edit	Energy:Diesel, combusted in industrial equipment	93.8113	L	3955.51	0.00	299.76	0.00
Edit	Energy:Electricity	921.3617	kWh	7870.37	0.00	442.15	0.00
Edit	Pesticides:Insecticide - active ingredient	14.0886	kg	6801.36	0.00	418.42	2.19
Edit	Pesticides:Herbicide - active ingredient	1.9972	kg	931.34	0.00	56.66	0.25
Edit	Pesticides:Fungicide - active ingredient, other than sulfur	14.1277	kg	5417.69	0.00	359.60	2.19
Edit	Pesticides:Fungicide - sulfur	0.1123	kg	13.89	0.00	0.87	0.02
Edit	Pesticides:Pesticide formulation - miscible oil	12.3084	kg	1547.06	0.00	109.52	1.91
Edit	Pesticides:Pesticide formulation - wettable powder	27.1289	kg	288.55	0.00	20.70	4.21
Edit	Fertilizers:Nitrogen - synthetic, other than CN/CAN and Urea	44.9061	kg	1425.93	0.00	73.37	21.11
Edit	Fertilizers:Phosphorous - synthetic	14.1454	kg	94.95	0.00	6.57	2.19
Edit	Fertilizers:Potassium - synthetic	60.6232	kg	674.59	0.00	46.34	9.40
Edit	Fertilizers:CN/CAN nitrogen	24.1236	kg	865.35	0.00	90.95	11.34
Edit	Micronutrients:Zinc	0.6736	kg	49.39	0.00	2.68	0.10
Edit	Micronutrients:Manganese	0.6736	kg	36.05	0.00	2.44	0.10
Edit	Micronutrients:Copper	3.3680	kg	240.26	0.00	13.29	0.52
Edit	Micronutrients:Calcium	0.3368	kg	1.35	0.00	0.10	0.05
Edit	Soil Amendments:Lime	13.4718	kg	28.49	0.00	2.17	2.09
Edit	Other Inputs:Cost of custom work	9373.3200	$	7265.92	1956.00	360.05	0.00
Edit	Pesticides:Pesticide - mineral oil	23.9773	kg	1589.78	0.00	44.26	3.72
Edit	Gaseous Waste:Carbon Dioxide	0.1417	kg	0.00	0.00	0.14	0.00
Edit	Fertilizers:Nitrogen - synthetic, other than CN/CAN and Urea	44.9061	kg	1425.93	0.00	73.37	21.11
Edit	Soil Emissions:N2O from nitrogen/urea	0.0000		0.00	0.00	699.88	0.00
Edit	Soil Emissions:CO2 from urea/lime	0.0000		0.00	0.00	5.87	0.00
Edit	Soil Emissions:N2O from crop residue/biological nitrogen fixation	0.0000		0.00	0.00	0.00	0.00
Edit	Carbon Sequestration:Biomass carbon incorporated in perennial crop	0.0000		0.00	0.00	-71.89	0.00
Edit	Manure Emissions:N2O from manure management	0.0000		0.00	0.00	0.00	0.00
Edit	Manure Emissions:CH4 from manure management	0.0000		0.00	0.00	0.00	0.00
Edit	Enteric Emissions:CH4 from enteric fermentation	0.0000		0.00	0.00	0.00	0.00
Edit	**TOTAL**:	0.0000		41796.92	3053894.80	3142.81	82.50

Legend: EE = Embodied Energy (total), MJ; EW = Embodied Water (total), L; EC = Embodied Carbon (total), Kg CO2e; TC = Carbon from Transport, Kg CO2e.

Normalized Summary Results:

Embodied Energy = 11.65 MJ/kg

Embodied Water = 851.10 L/kg

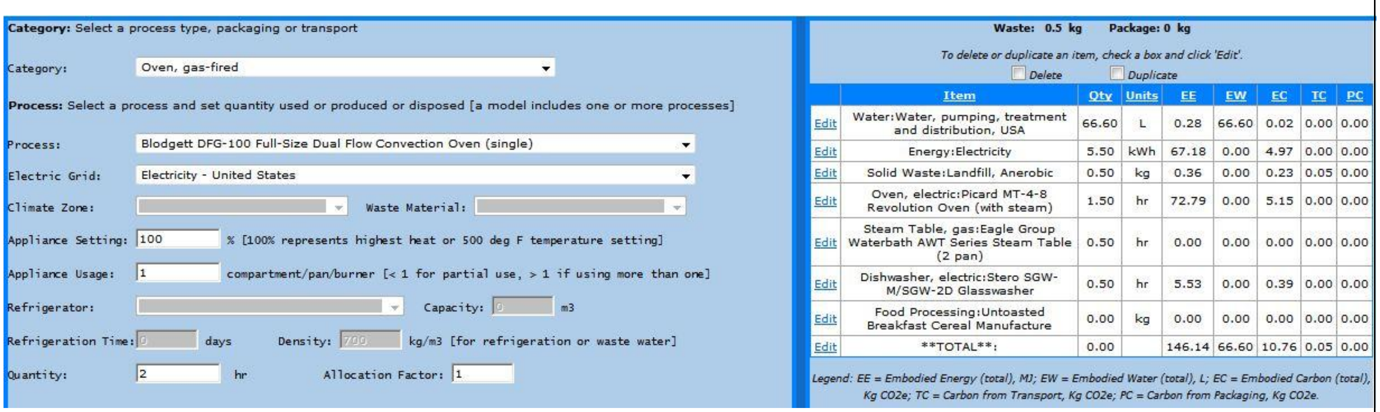
Embodied Carbon = 0.88 Kg CO2e/kg

Processing model

The next screenshot shows the modeling of a food processing stage. A processing model can include:

- Generic food processing methods
- Commercial cooking appliances
- Refrigeration
- Packaging
- Fuel and electricity use
- Water use
- Waste disposal
- Transport

The purpose of a processing model is to capture all the additional resource-consuming and emissions-generating steps beyond the production stage until the product enters the distribution network. This can happen at or near the farm, or more likely at a centralized facility that uses ingredients from multiple production locations. The built-in food processing methods and the extensive selection of cooking appliances available in the LCI database significantly ease the task of developing processing models. Alternately, users can model their proprietary processing methods by directly inputting fuel/electricity use, along with other details such as water use, waste generation and packaging.

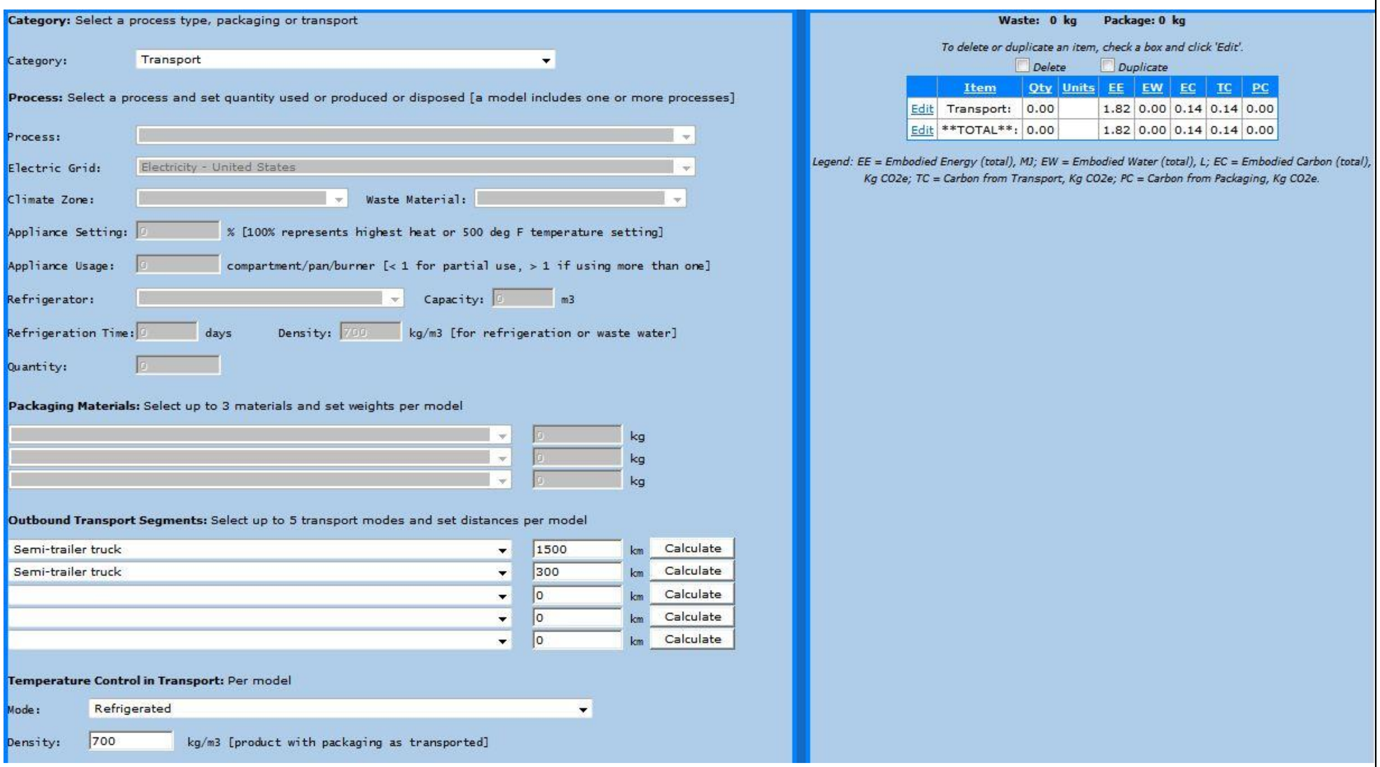


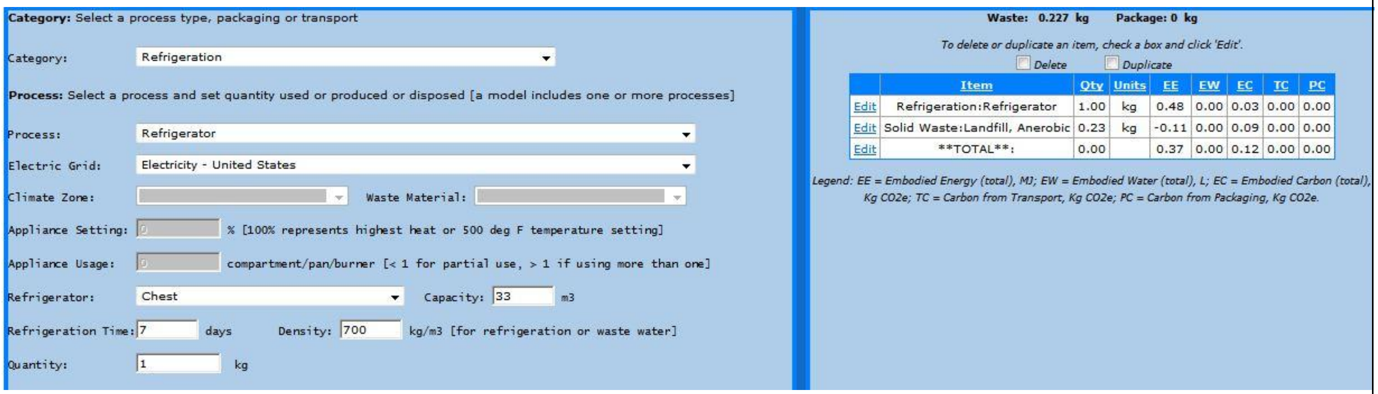
	Item	Qty	Units	EE	EW	EC	TC	PC
Edit	Water:Water, pumping, treatment and distribution, USA	66.60	L	0.28	66.60	0.02	0.00	0.00
Edit	Energy:Electricity	5.50	kWh	67.18	0.00	4.97	0.00	0.00
Edit	Solid Waste:Landfill, Anerobic	0.50	kg	0.36	0.00	0.23	0.05	0.00
Edit	Oven, electric:Picard MT-4-8 Revolution Oven (with steam)	1.50	hr	72.79	0.00	5.15	0.00	0.00
Edit	Steam Table, gas:Eagle Group Waterbath AWT Series Steam Table (2 pan)	0.50	hr	0.00	0.00	0.00	0.00	0.00
Edit	Dishwasher, electric:Stero SGW-M/SGW-2D Glasswasher	0.50	hr	5.53	0.00	0.39	0.00	0.00
Edit	Food Processing:Untoasted Breakfast Cereal Manufacture	0.00	kg	0.00	0.00	0.00	0.00	0.00
Edit	**TOTAL**:	0.00		146.14	66.60	10.76	0.05	0.00

Legend: EE = Embodied Energy (total), MJ; EW = Embodied Water (total), L; EC = Embodied Carbon (total), Kg CO2e; TC = Carbon from Transport, Kg CO2e; PC = Carbon from Packaging, Kg CO2e.

Distribution and retail models

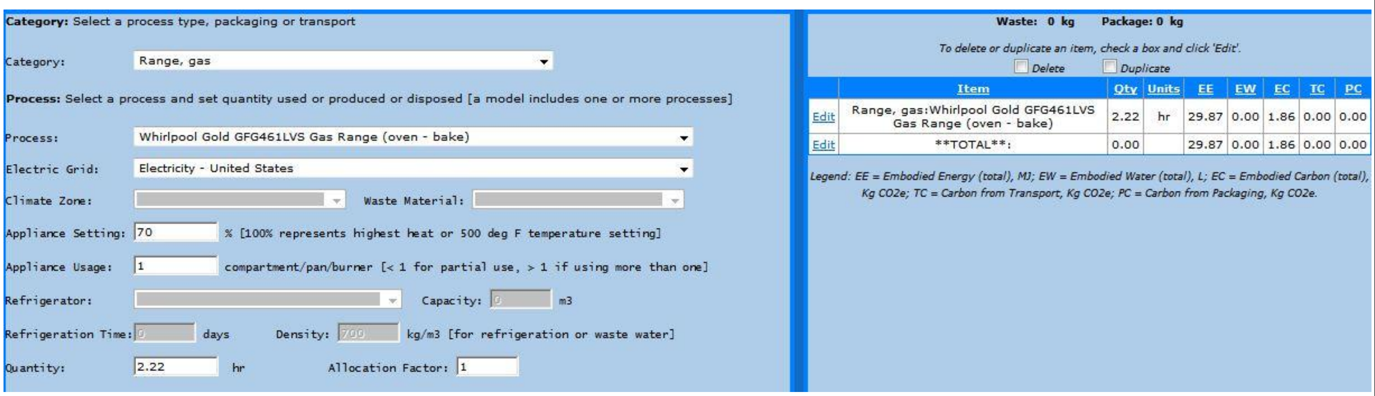
Distribution and retail models are similar to processing models except that they do not include food processing methods and cooking appliances. A distribution model can contain one or more storage facilities, such as warehouses with optional refrigeration, and one or more transport links. Transport can include all common transport modes (road, rail, ocean and air). A distribution model can also include packaging and waste disposal for situations where products are repackaged at a warehouse before further shipping and for cases where there are product losses due to spoilage or breakage. The purpose of a retail model is to capture the energy use and any product waste at a retail location, as well as any repackaging or additional packaging and transport from retail. The next two screenshots illustrate examples of these.





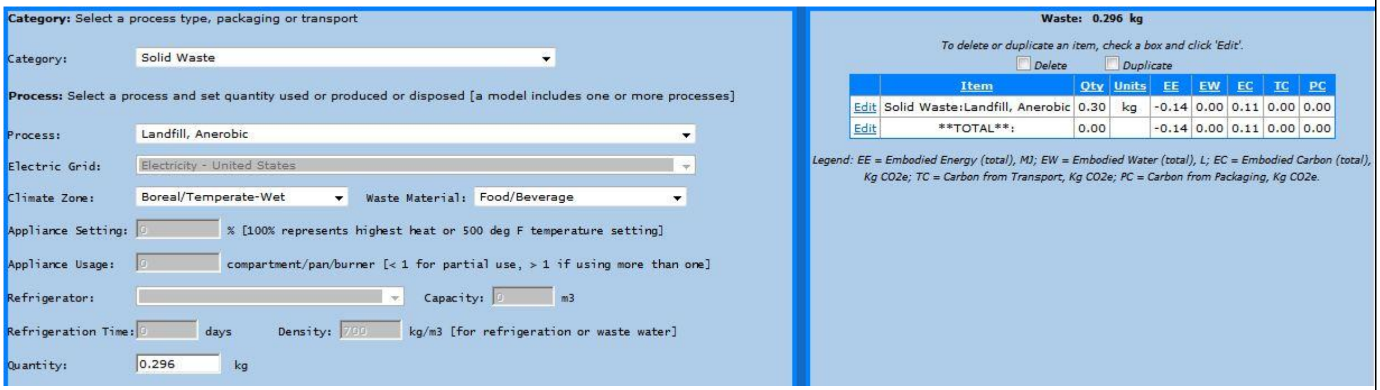
Cooking or food service model

A cooking or food service model, shown in the following screenshot, is identical to a processing model except that it does not include the built-in food processing methods. The purpose of a cooking model is to capture the resource use and emissions during the preparation of meals and drinks at restaurants, coffee shops, food service facilities, and the like.



Consumption model

Finally, a consumption model, shown below, can include additional refrigeration, waste disposal, and the use of energy and water. Note that not all life cycle stages are required in a life cycle model, and there can be more than one instance of some stages in more detailed models – thus, the user has a high degree of flexibility in constructing product life cycle models that range from the simple to the complex.



Analysis

Once a product life cycle model has been developed, the click of a button generates the LCA results. In keeping with the philosophy of combining an easy-to-use interface with rigorous analysis, FoodCarbonScope™ handles many of the routine details automatically under the hood. Examples of this include:

- Ensuring correct material flows and mass balances throughout the life cycle tree, accounting for the final product quantity that is actually delivered or consumed[8] and all product/material wasted throughout the supply chain.
- Disposal of prior packaging materials when a packaged product undergoes additional packaging or repackaging at any stage and when a product is finally consumed.
- Accounting of credit for typical energy recovery from waste disposal methods such as landfilling and incineration.
- Accounting for the timing of the various GHG emissions and carbon sequestration events, as described further in the methodology section.

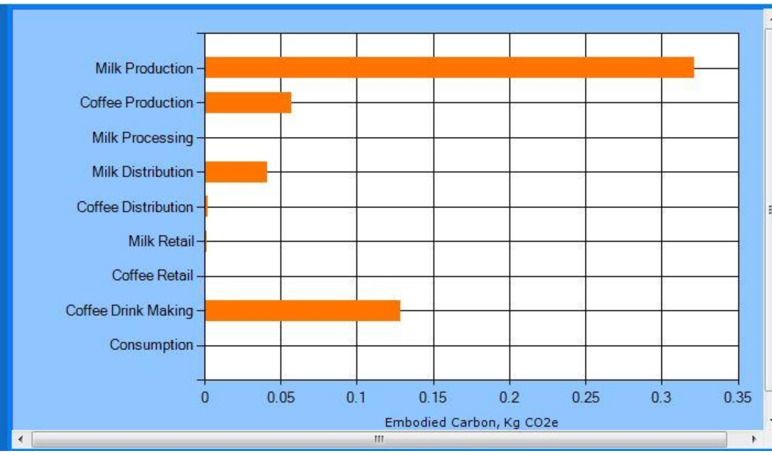
What do the results look like?

FoodCarbonScope™ presents the analysis results in multiple forms, two of which are illustrated below. **Results by life cycle stage** show the quantity of material at the output of each stage along with the embodied energy (primary energy used), embodied carbon (GHG emissions generated) and embodied water (water used) at that stage. Additional details include the emissions contributions from transport, packaging and waste disposal.

[8] This is known as the functional unit, which the user defines in a typical analysis.

Name	Type	Model Weight	Scaled Weight	Embodied Energy	Embodied Water	Embodied Carbon	Transport Carbon
Milk Production	Production	0.19	0.35	2.33	59.05	0.32	0.03
Coffee Production	Production	0.01	0.02	0.69	0.68	0.06	0.00
Milk Processing	Processing	1.00	0.35	0.00	0.00	0.00	0.00
Milk Distribution	Distribution	1.00	0.35	0.54	0.00	0.04	0.04
Coffee Distribution	Distribution	1.00	0.02	0.03	0.00	0.00	0.00
Milk Retail	Retail	1.00	0.35	0.02	0.00	0.00	0.00
Coffee Retail	Retail	1.00	0.02	0.00	0.00	0.00	0.00
Coffee Drink Making	Cooking	0.24	0.36	3.16	0.33	0.13	0.00
Consumption	Consumption	1.00	0.36	0.00	0.00	0.00	0.00
TOTAL	**TOTAL**	0.36	0.36	6.77	60.06	0.55	0.07

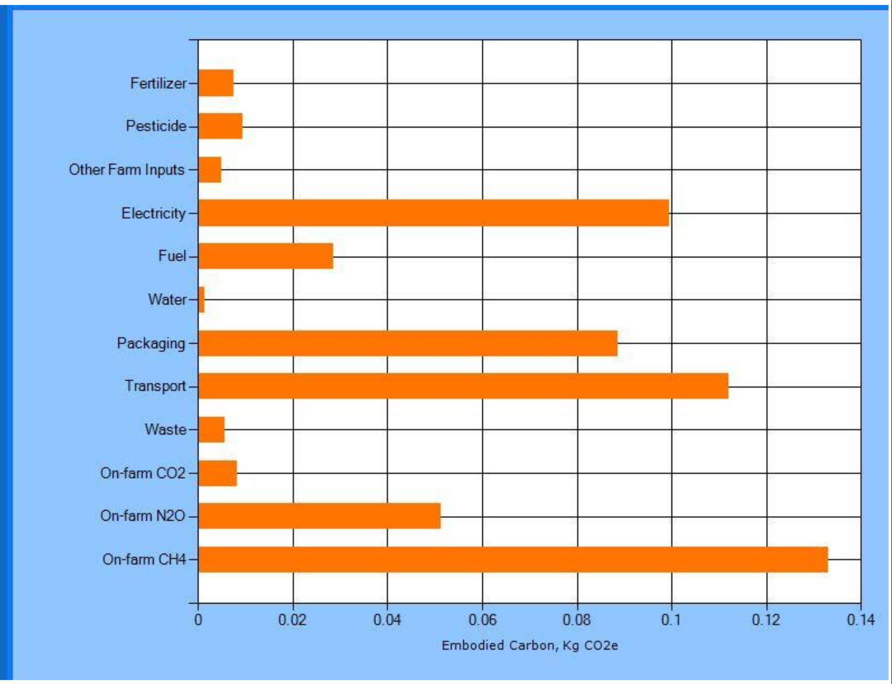
Note: All weights in Kg. All carbon in Kg CO2e. Energy in MJ. Water in L. "Embodied" figures are total values for each life-cycle stage. Scaled weight is the actual weight at the output of each life-cycle stage, based on quantities consumed and wasted downstream.



Results by GHG emissions inventory drill down to the emissions contributions from all the basic input materials and energy used throughout the product life cycle, as well as from transport, packaging and waste disposal. Note that the life cycle assessment traces all of the input materials, energy and processes all the way back to the point of resource extraction from the ground. Also included in these results are the direct and indirect GHG emissions and carbon sequestration at the farm level: nitrous oxide (N2O) from nitrogen fertilizer application, crop residues, biological nitrogen fixation, changes in tillage practices, and manure management; methane (CH4) from flooded rice fields, manure management, and enteric fermentation; carbon dioxide (CO2) from lime/urea application and oxidation of soil organic matter; and carbon sequestration in soils and biomass.

Emission Source	Embodied Carbon (Kg CO2e)
Fertilizer	0.008
Pesticide	0.009
Other Farm Inputs	0.005
Electricity	0.099
Fuel	0.029
Water	0.001
Packaging	0.089
Transport	0.112
Waste	0.006
On-farm CO2	0.008
On-farm N2O	0.051
On-farm CH4	0.133
TOTAL	0.550

Note: The agricultural input processes above -- such as fertilizers and pesticides -- are cradle-to-gate. The packaging, transport and waste emissions above are from processes that occur after the production of these inputs.



Other report views include results by process/activity and results for each model element, as well as supporting documentation such as detailed life-cycle inventory data sources for each model element. All results can be exported to an Excel file.

More on methodology

This section provides additional detail on the modeling and analysis methodology used in FoodCarbonScope™ and within the LCI database in four key areas: **agricultural processes, waste disposal, co-product allocation, and timing-dependent emissions/sequestration**.

Agricultural processes

Agricultural processes are the foundation for all LCAs of foods and beverages, and are modeled uniformly in FoodCarbonScope™ based on a detailed inventory of inputs and outputs. This applies to the standard agricultural products in the LCI database as well as custom products created by users.

Inputs and outputs of agricultural models include:

- Fertilizer inputs (both synthetic and organic)
- Pesticide inputs
- Other inputs such as lime, gypsum, sulfur, etc.
- Irrigation -- including district-supplied water, ground water (pumped), and surface water from natural sources such as rivers
- Electricity and fuel use
- Feeds for animals
- Transport of material inputs to farm
- Any processing of raw products
- Disposal of solid waste and waste water
- Non-energy GHG emissions and sequestration at the farm level:
    - CO2 from lime and urea application
    - Direct/indirect N2O emissions from soils and water due to nitrogen fertilizer application (both synthetic and organic)
    - Direct/indirect N2O emissions from soils due to crop residues, biological nitrogen fixation and changes in tillage practices

  - CH4 from flooded rice fields
  - CH4 from enteric fermentation in ruminant animals
  - CH4 and N2O emissions from manure management
  - Carbon sequestration in the biomass of perennial species such as fruit trees during growth and at maturity
  - Changes in the carbon content of soils (emissions/sequestration) due to land-use changes and land management methods – including changes related to tillage, application of organic amendments, etc.
- All inputs, outputs and emissions occurring during the establishment years for perennial species such as fruit trees
- All inputs and emissions related to the planting and maintenance of cover crops

The analysis is based on LCI data from CarbonScopeData™ for material inputs such as fertilizers, pesticides and soil amendments, energy sources such as fuels and electricity, transport and waste disposal. These LCI data are in the form of "cradle to gate" for materials (including combustion for fuels), "cradle to grid" for electricity (based on fuel mixes in each grid region and accounting for transmission line losses), "well to wheels" for transport, and "gate to grave" for waste disposal. Typical or nominal transport distances are included for all material and fuel inputs.

Waste disposal

Waste typically occurs at multiple points in a food/beverage life cycle. This includes food waste at processing, retail, cooking and consumption as well as the disposal of packaging materials. FoodCarbonScope™ models both solid waste and waste water streams in detail based on methodologies and parameters adapted from the IPCC guidelines. Solid waste modeling includes aerobic/anaerobic landfilling, incineration, composting, and recycling/reuse. Waste water modeling includes aerobic and anaerobic treatments. Methane and energy recovery options are built into waste processing steps and credits are automatically included in the energy and emissions calculations.

Recycling is modeled in FoodCarbonScope™ using the "recycled content" method which allocates the costs and benefits of recycling to the input side of product systems. The system boundaries are defined such that the system that produces the recyclable waste is responsible up to the point of delivering the waste to a recycling facility, and then any subsequent transport, processing and use of that material is included within other systems that use the material in some form.

Other types of waste material that may be useful elsewhere, such as manure from animal systems, are handled in a similar manner: The product systems that use the material, such as organic crop systems that use manure as a substitute for fertilizers, get credit for avoiding the resource use and emissions associated with fertilizer manufacture; and these systems also bear the burden of actually applying the manure and the subsequent N2O emissions from the soil.

Co-product allocation

Some production and processing systems generate more than one useful output. Allocation of resource use and emissions between such co-products comes up frequently in LCAs. FoodCarbonScope™ allows users to set "allocation factors" in custom agricultural production, food processing and cooking models. Users can avoid allocation by dividing a process into distinct sub-processes, or they can set allocation factors based on mass-weighted economic value or a biophysical measure (such as mass, energy or nutrition content) as appropriate. FoodCarbonScope™ does not support system expansion because of the inherent difficulties and uncertainties involved in identifying and characterizing appropriate marginal product systems.

Time-dependent emissions and sequestration

Not all GHG emissions occur instantaneously during production and consumption. Emissions from decomposing waste in a landfill, for example, may occur over multiple decades. GHG emissions (both CO2 and N2O) and carbon sequestration related to land-use changes and management practices are also long-term processes. Carbon sequestration in the biomass of growing perennial crops is another long-term process. FoodCarbonScope™ models such dynamic, or time-dependent, GHG emissions and carbon sequestration by explicitly considering the time dimension over an assessment period[9]. Emission and sequestration events are weighted according to the timing of the events within the assessment period, in compliance with PAS 2050 and as part of our Deep Carbon Footprinting™ methodology.

[9] The standard assessment period is 100 years, but users can change this as needed.

Company info

CleanMetrics Corp., based in Portland, Oregon, is dedicated to solving problems in environmental sustainability through innovative software tools, databases and consulting services grounded in robust analytical techniques. CleanMetrics is a leader in applying quantitative methods to produce practical sustainability solutions that you can put to use in your business every day.

The founders of CleanMetrics believe that the best analytical solutions start with a thorough understanding of the target industry or problem domain, which often comes from years of working in the trenches to solve a variety of practical problems for customers. From there, it is a matter of bringing together the right expertise in algorithms, modeling and software/database design to create tools that can standardize, automate and simplify complicated tasks.

CleanMetrics and its predecessor Surya Technologies have successfully provided modeling, analysis, optimization and simulation software and technologies to a broad range of customers in the semiconductor and electronic design automation industries in the US, Japan and India since the mid-1990s. CleanMetrics is now leveraging that expertise to provide rigorous and quantitative sustainability solutions to customers worldwide.

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