Fairglow White Paper

Fairglow

Background

In recent years, the cosmetics industry has experienced a profound transformation, with a growing emphasis on sustainability. Increasingly, brands, laboratories and retailers are recognizing the urgent need to measure and reduce their environmental footprint. Upcoming regulations such as the CSRD (taking effect in January 2024), and the European Directive on Green Claims, as well as the rising demand from eco-conscious customers make sustainability a must-have for anyone in the cosmetics industry. **Measuring one's carbon footprint and conducting life cycle assessments (LCAs) have emerged as necessary elements of the cosmetics industry.**

Conducting an LCA is the only way to truly understand the environmental impact of a product throughout its entire lifecycle. From raw material extraction and production to distribution, use, and disposal, there are many complex elements to the cosmetics value chain. It is only by adopting a holistic approach that companies can gain a deep understanding of their products' ecological footprints and act to effectively decrease their environmental impact.

Currently, carbon footprinting and LCAs are arduous, long, and expensive. Many companies rely on specialized consultants to navigate the intricacies of these assessments manually. As the demand for sustainable practices rises, traditional approaches no longer satisfy the needs of the cosmetics industry.

To address these challenges, we are proud to introduce **Fairglow: the first and only cosmetics-specific Carbon Management Platform** that helps labs, brands and retailers discover the exact sources of their environmental impact and take actionable steps to reduce their footprint. Our cutting-edge technology not only ensures the same level of accuracy and precision as traditional manual assessments but also streamlines the entire process. By automating the labor-intensive aspects of carbon footprint analysis and life cycle assessments, our solution empowers cosmetics companies to make informed, sustainable decisions without incurring excessive costs, human resources, or time delays.

With our Carbon Footprint Automation, cosmetics brands can embrace sustainability with confidence, meeting the demands of both regulatory bodies and environmentally-conscious customers. By simplifying and accelerating the sustainability assessment process, we pave the way for a greener and more ecologically responsible future for the cosmetics industry.

Here-below we explain our process and how we deliver fast, reliable and affordable results to our customers.

But how does Fairglow work?

Fairglow uses a combination of methodologies and data, proprietary techniques, and algorithms to provide carbon footprints, assist in more sustainable formulation, and optimize cosmetic value chains.

In this paper we describe the fundamentals of our methodology, and give a description of the methods, data, techniques, and algorithms deployed.

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I. How Fairglow’s environmental footprints work

A. Life Cycle Analysis

Life Cycle Analysis (LCA) is a comprehensive methodology within the field of environmental sustainability that quantifies the environmental impacts of a product, process, or system throughout its entire life cycle. LCA encompasses a systematic approach that evaluates the inputs, outputs, and potential environmental consequences at each stage of a product’s value chain or life cycle. These stages include raw material extraction, production, use, and disposal. The process involves collecting data on material and energy flows, emissions, and resource consumption at each life cycle stage. These data are then used to construct a life cycle inventory (LCI), which forms the foundation of the analysis. Mathematical models and analysis techniques are applied to the LCI to assess the potential environmental impacts.

Fairglow calculates environmental footprints by using LCA data and processes.

The impacts covered by Fairglow match the EU Product Environmental Footprint (PEF) and are listed below.

Impact Categories

No.	PEF Impact Category	Description	Unit
1	Climate Change	Measures potential global warming impacts through greenhouse gas emissions.	kg CO2 eq
2	Ozone Depletion	Measures potential ozone layer depletion impacts through emissions of ozone-depleting gases.	kg CFC-11 eq
3	Human Toxicity (HTP)	Measures potential human toxicity, including carcinogens and non-carcinogens.	CTUh
4	Freshwater Eutrophication (FEP)	Measures potential eutrophication impacts in freshwater bodies.	kg P eq
5	Marine Eutrophication (MEP)	Measures potential eutrophication impacts in marine ecosystems.	kg N eq
6	Terrestrial Acidification (TAP)	Measures potential acidification impacts on terrestrial ecosystems.	mol H+-eq
7	Freshwater Ecotoxicity (FET)	Measures potential ecotoxic impacts in freshwater ecosystems.	CTUe
8	Marine Ecotoxicity (MET)	Measures potential ecotoxic impacts in marine ecosystems.	CTUe
9	Terrestrial Ecotoxicity (TET)	Measures potential ecotoxic impacts in terrestrial ecosystems.	CTUe
10	Abiotic Resource Depletion (ARD)	Measures potential depletion of abiotic resources.	kg Sb-eq
11	Fossil Resource Depletion (FRD)	Measures potential depletion of fossil resources.	MJ surplus
12	Ionising Radiation (IOR)	Measures potential ionizing radiation impacts.	kg U235 eq.
13	Particulate Matter (PM)	Measures potential human health impacts due to inhalable particles.	kg PM 2.5 eq
14	Photochemical Ozone Formation (POF)	Measures potential contribution to photochemical ozone formation.	kg NMVOC eq.
15	Water Depletion (WD)	Measures potential depletion of water resources.	m3 eq
16	Land Use (LU)	Measures potential land use impacts.	m2a

This list provides an overview of the 16 PEF impact categories and their associated units used for assessing the environmental performance of products.

What inputs does Fairglow use?

We utilize all the available information you have about your product. As a rule, when conducting a carbon footprint, the more input data you have, the more accurate your carbon footprint will be. Each carbon footprint we generate for cosmetic products utilizes well over one hundred data fields. To list them all here would be excessive. However, we can discuss the most common data values our clients provide, and the relative importance to the overall calculation.

User Inputs by Value Chain Category

Ingredients

Data Field	Description	Importance to Accuracy	Why It Matters
Ingredients List	Text description	High	You need to know at least the names of the ingredients to start measuring the impact of a cosmetic product.
Ingredient Concentration	Numeric or range	Medium	Knowing the quantity of ingredients in the formulation is important. Fairglow can use its ingredient estimation algorithm to give concentrations with a high degree of accuracy, and ensure your formula remains secret.
Ingredients Country Origin	Country of origin	Medium	Knowing the origin of the ingredient helps to estimate the ingredient's emissions from electricity and heating of factories, and land use effects.
Ingredients Upstream Transport	Methods and Distance	Low	Typically, a small percentage of the overall ingredient's footprint.

Packaging

Data Field	Description	Importance to Accuracy	Why It Matters
Packaging Material	Plastic, Metal, Ceramic, etc	High	Packaging materials vary drastically in their overall impact based on their composition.
Packaging Mass & Volume	Numeric or range	High	Knowing the quantity of ingredients in the formulation is vital to the final impact. Fairglow can use our ingredient estimation algorithm to give a high-degree of accuracy, and ensure your formula remains secret.
Manufacturing Process	Method of production	Medium	Plastics are extruded in different ways, for example, and the method is impactful for the overall footprint.
Packaging Country Origin	Country of origin	Medium	Knowing the origin of the packaging helps to estimate the ingredient's emissions from electricity and heating of factories, and land use effects.
Packaging Upstream Transport	Methods and Distance	Low	Typically, a small percentage of the overall packaging footprint.

Manufacturing

Data Field	Description	Importance to Accuracy	Why It Matters
Manufacturing Electricity	Numeric	High	Electricity is typically one of the largest emissions sources in the manufacturing stage.
Manufacturing Heating	Numeric	High	Industrial heating is typically one of the largest emissions sources in the manufacturing stage.
Manufacturing Country Origin	Country of origin	Medium	For calculation of the electricity, heating, and water environmental costs.
Manufacturing Water	Numeric	Low	Water usage of the factory processes.
Manufacturing Equipment	Taken from List	Low	Types of equipment deployed in the processes.
Manufacturing Cleaning Process	Material Inputs	Low	Methods and inputs for cleaning equipment after the formulation processes.
Factory cubic meterage	Numeric	Medium	Amortizing the building size across total lifetime production often yields a reasonably high impact.

Transportation

Data Field	Description	Importance to Accuracy	Why It Matters
Method	From List	High	Transportation from point A to B can have vastly different impacts according to the method deployed.
Distance	Numeric	High	You need distance.

Use

Data Field	Description	Importance to Accuracy	Why It Matters
Geography	Numeric	High	Geography allows us to calculate relevant emissions factors for the usage of the product.
Usage	Text description	High	How much energy or other inputs are expected to be used during the lifetime of the product.

End of Life

Data Field	Description	Importance to Accuracy	Why It Matters
Geography	Numeric	High	Geography allows us to calculate relevant emissions factors for the waste treatment of the product.

B. Our Data

To excel as a leading environmental footprint analysis company for cosmetics, the foundation must be laid with robust data. Fairglow has three main competitive advantages when it comes to our data.

Cosmetic Product Data

Fairglow harnesses a vast database comprised of more than 50,000 cosmetic products. This resource empowers us to make well-informed choices pertaining to your product, supply chain, and more. Our comprehensive database meticulously records and preserves essential data points from a diverse array of cosmetic products available for purchase online.

Ingredients Data

We have a database containing every listed **International Nomenclature of Cosmetic Ingredients (INCI).** This data contains a variety of fields that are useful and necessary to understand and conduct LCA on cosmetic formulations. To this database we add the ingredient’s possible functions, toxicological data, and more, to provide heft and accuracy to our algorithms. Rich ingredient level data helps us to identify potential improvements to formulations, and help formulators make sustainable decisions.

Emissions Factors Data

Fairglow leverages a proprietary database of over 2,000, cosmetic industry specific emissions factors.

In addition to Fairglow’s cosmetic specific data, Fairglow utilizes the industry standard EcoInvent databases for many of its processes and emissions calculations.

Whenever possible, Fairglow uses primary data provided by actors in our partners value chain. Fairglow can assist our partners in acquiring the data most impactful for creating an accurate estimate.

C. Ingredient Concentration Algorithm

While cosmetic ingredient lists are public knowledge, exact formulations are deeply guarded secrets. Even when Fairglow is working closely with a cosmetic formulator, there may be the need to keep an exact formulation private. Fairglow can make accurate estimates of our customer's carbon footprint without requiring exact formulations. **Leveraging our knowledge of cosmetic formulations, and our vast database of cosmetics products, we can estimate the ingredient concentrations present in any cosmetic product.**

There are certain chemical functions that must be present in specific concentrations for a product to behave properly within a product category. For instance, any facial cleanser will need ingredients called surfactants, to help remove dirt and clean skin. By knowing the ingredient list and the product category we can infer the concentrations of each ingredient to within a few percentage points of accuracy.

Ingredient lists also often hold additional clues to the ingredient concentrations, including: (1) the order of appearance in the ingredient list, (2) whether it's an active or inactive ingredient, and (3) sometimes even exact concentrations of certain ingredients. When those concentrations are present, they can then anchor the concentrations of other ingredients in the list.

Our methodology allows instantaneous calculation of ingredient concentrations that are suitable for carbon footprinting and allow formulators to keep their precise concentrations secure and private.

There is much more to say about our exact methodology*:* ***please reach out to learn more*****.**

D. Conditional Interpolation Algorithm

Traditional carbon footprint estimation demands a comprehensive dataset encompassing numerous product-specific attributes. However, the reality often involves incomplete information due to time constraints, data availability, or evolving product configurations. **Our Conditional Interpolation Algorithm is the powerful technology at the core of Fairglow; designed to bolster the precision of carbon estimates while accommodating varying levels of input data availability.**

Conditional Interpolation leverages the power of advanced mathematical algorithms to strategically fill in missing inputs based on the provided data.

A key feature of this approach is its contextual sensitivity. The technique considers the intrinsic relationships between inputs, ensuring that interpolated values align with the specific attributes provided by the customer. This nuanced approach guarantees that the resultant carbon estimates are grounded in real-world correlations, making them both reliable and extremely fast.

E. Detailed Example

Example product: facial cleanser

Here we break down a Fairglow's Conditional Interpolation into the six dimensions of a typical life cycle assessment, including in-depth descriptions of each step. For this example product, we assume that only the following data were provided:

INPUT DATA

- **Product Name**: Example Facial Cleanser
- **Product category**: Facial Cleanser
- **Size/Volume**: 150ml

- **Ingredients List (from packaging)**: MINERAL OIL (PARAFFINUM LIQUIDUM), PEG-8 GLYCERYL ISOSTEARATE, CETYL ETHYLHEXANOATE, ISODODECANE, WATER (AQUA), ISOSTEARIC ACID, GLYCERIN, SD ALCOHOL 40-B (ALCOHOL DENAT.), FRAGRANCE (PARFUM), VITIS VINIFERA (GRAPE) SEED OIL, BHT, TOCOPHEROL

With this limited amount of input data, Fairglow uses Conditional Interpolation to assign the most relevant data assumptions to calculate the most accurate carbon footprint possible. Our system compares the product with our database of cosmetic products and fills in all the data gaps with the best possible estimate.

Ingredients

Determining the carbon footprint of a cosmetic product's ingredients involves two main steps.

1. First, **Fairglow uses its *Ingredient Concentration Algorithm***. As with all other steps of Fairglow's life cycle assessment, our clients can seamlessly check and correct any assumption our software made with actual data.
2. Once we estimate the concentration of each ingredient, **our algorithms assign upstream transportation values, and chemical origination values**. These values all are relevant to the total environmental footprint of each ingredient.

Example of the Interpolated values seen below:

Ingredient	Function	Estimated Conc. %	Upstream Transport - Lorry (kgkm)	Origin
MINERAL OIL (PARAFFINUM LIQUIDUM)	Emollient	18.4	124	Synthetic - Hydrocarbon
PEG-8 GLYCERYL ISOSTEARATE	Emulsifier	15.2	102	Synthetic - Hydrocarbon
CEYL ETHYLHEXANOATE	Emollient	14.9	100	Synthetic - Other
ISODODECANE	Emollient	11.1	75	Synthetic - Hydrocarbon
WATER (AQUA)	Solvent	10.3	69	Natural
ISOSTEARIC ACID	Emulsifier	9.2	62	Synthetic - Other
GLYCERIN	Humectant	6.7	45	Natural
SD ALCOHOL 40-B (ALCOHOL DENAT.)	Solvent	5.5	37	Synthetic - Hydrocarbon
FRAGRANCE (PARFUM)	Fragrance	5.4	36	Synthetic - Other
VITIS VINIFERA (GRAPE) SEED OIL	Emollient	1.4	9	Natural
BHT	Antioxidant	1.0	7	Synthetic - Other
TOCOPHEROL	Antioxidant	0.8	6	Natural

Everything except the ingredients list above is derived from the interpolation algorithm. Any of these values can be updated to fit each company's precise supply chain and production methods, thereby making the input value precise.

Packaging

Packaging assumptions for a facial cleanser involve the production of two primary packaging elements and one secondary packaging element. Packaging assumptions are made in the same way that Fairglow makes all its assumptions: ***via data science to arrive at the best estimation for the data gaps***. In this case, we only know the product is a 150ml bottle of facial cleanser, however our algorithm has made the below assumptions for the example product.

Type 1	Steps	Packaging Tier 1	Packaging Tier 2	Packaging Tier 3
Materials	Packaging Tier	Primary	Primary	Secondary
Materials	Material	PETg - Glycolised PET	Polypropylene	Corrugated cardboard box
Materials	Country	Global	Global	China
Materials	End of Life	Rigid	Rigid	Food Brick
Materials	Mass (g)	30	10	40
Materials	Recycled Material	rPETg - Glycolised PET – Europe	Recycled Polypropylene - Europe	Recycled Corrugated cardboard
Materials	Recycled Rate	40%	5%	20%
Process	Transformation Process	Injection Molding	Injection Molding	Cardboard box production, w/ gravure printing
Process	Country	Global	Global	China
Process	Scrap Rate	0.6%	0.6%	20%
Process	Upstream Transport	National Scenario	National Scenario	International (ship)

***The Conditional Interpolation Algorithm* makes these packaging assumptions automatically based on our large database of cosmetic products.**

These assumptions would change if we had different data for our product, such as if the product was 50ml, or if we knew that packaging configuration was a flip-top cap, instead of a simple pump dispenser.

Manufacturing

Manufacturing is a critical step in cosmetics production. Typically, for an oil-based facial cleanser product, our algorithms break down the different steps as described in the table below. Such a product is most likely made in a laboratory with a low-heat mixing process, which is modelled below with some default values for an average laboratory, doing an average mixing process.

LCA Phase	Manufacturing Process	Description	Value Description	Value	Unit
Input, Energy	Mixing/Blending, Process	Combining ingredients to create a homogeneous mix	Energy: Electricity	2.40	kWh
Input, Energy	Mixing/Blending, Process	Combining ingredients to create a homogeneous mix	Energy: Heat	27.00	MJ
Input, Material	Mixing/Blending, Infrastructure	Laboratory Building	Building Emissions, Multi Story	0.00	m^3
Input, Material	Mixing/Blending, Infrastructure	Mixing equipment	Steel; chromium Steel 18/8	6.58	g
Input, Material	Mixing/Blending, Cleaning	Ethanol Cleaning Procedure	Ethanol; 95% solution	0.40	g
Waste	Mixing/Blending, Waste	Wastewater emissions	Wastewater treatment	0.21	L

As with the other phases of a cosmetic product's life cycle, these interpolations are based on industry averages**. If we are provided with more data about our clients' products' production facilities, such as power bills, equipment used, or even the square meterage of the facility, our system ingests that data and updates your carbon footprint instantly.**

Distribution

This phase covers transport from manufacturing to retail. This figure can be difficult to determine due to the complexities of distribution for modern packaged goods. This value is a default distribution value for a facial cleanser, measured in the standard freight context of *kgkm* for a European market.

Transport Type	kgkm	Description
Truck, general cargo, 3.5-7.5t, Europe	150	For European transport of this type, the associated emission factor is 1.7g CO2 per kgkm

Like for any other dimensions, if we are provided with one or a dozen of inputs regarding distribution, our system ingests that data and updates the distribution carbon footprint instantly.

Use

The use phase typically represents the largest category of environmental impacts, at least considering carbon emissions. Cosmetics companies can do little to control this phase of their product's life cycle. Nonetheless, having an estimation is important for measuring a product's *Scope 3* emissions.

LCA Stage	Description	MJ/Use	Total MJ
Energy Use	Based on category and geography; uses / bottle	1.6	80

End of Life

Once a product is used and its container is empty, the product is not done with its life cycle just yet. There is still waste treatment to be accounted for, and potential for energy or material reclamation. For the default values of such a product, there are some emissions to waste treatment systems to be accounted for, as well as recycling values. Their configuration is too complex to list here, so we merely describe the values.

End of Life	Value Description	Description
Energy Reclamation	Household recycling system - Europe	Blended description of the total recycling rates to European system
Material Output	Emissions to wastewater/air	Blended description of waste emissions based on chemical composition.

This example demonstrates the complexity and power of Fairglow's Conditional Interpolation algorithm.

II. How Fairglow can help formulators reduce emissions in cosmetic formulation

Environmental impact reduction is the ultimate goal of Fairglow. Our state-of-the-art LCA methodology makes it easier than ever to measure environmental impact in the cosmetic value chain. By measuring impact rapidly, partners can fully understand their product or portfolio from an environmental viewpoint. Measurement is the first step in any carbon reduction plan. But how else does Fairglow help users reduce their emissions?

Formulation Guidance

Many tools exist to assist formulators in optimizing their cosmetic formulations for price, for regulatory concerns, or for toxicological or chemical concerns. Only Fairglow can provide assistance in formulation for minimizing environmental impact. Fairglow can help formulate a product from scratch, or by taking an existing product formulation and assisting with chemical substitutions to reduce the overall impact. To make an appropriate ingredient substitution, Fairglow combines *Hansen Solubility Parameters* (HSP) and ingredient emission factors to find suitable molecular matches for a given formulation.

Hansen Solubility Parameters

HSPs are a set of values used to predict the solubility of different substances in various solvent mixtures. The parameters provide a quantitative way to understand the interactions between solvents and solutes, helping to predict whether a solute will dissolve in a particular solvent or solvent blend.

The HSP system is based on three main parameters:

1. **Dispersion Forces (δd):** Represents the strength of London dispersion forces or van der Waals interactions between molecules. It reflects the ability of a solvent to dissolve non-polar or hydrophobic substances.
2. **Polar Forces (δp):** Reflects the dipole-dipole interactions between molecules. It indicates the ability of a solvent to dissolve polar substances.
3. **Hydrogen Bonding Forces (δh):** Reflects the presence and strength of hydrogen bonding interactions. It signifies the ability of a solvent to dissolve compounds that can form hydrogen bonds.

Once you have the HSP values for two molecules, you can calculate the Euclidean distance between them. The Euclidean distance is a measure of the straight-line distance between two points in a multi-dimensional space (in this case, the HSP space). It considers the differences between the HSP values of the two molecules along each parameter.

The Euclidean distance formula for any arbitrary two molecules is as follows:

$$X_{Distance} = \sqrt{(\delta D_1 - \delta D_2)^2 + (\delta P_1 - \delta P_2)^2 + (\delta H_1 - \delta H_2)^2}$$

Where :

$\delta D_1, \delta P_1, \delta H_1$ *and* $\delta D_{2,}\ \delta P_{2,}\ \delta H_2$ are the Hansen Solubility Parameters of any two molecules.

Interpreting the Distance: A smaller Euclidean distance indicates that the HSP values of the two molecules are closer, implying a higher similarity in terms of solubility characteristics. A larger Euclidean distance indicates greater dissimilarity, and a lower likelihood that a given molecule would be a good substitute.

For purposes of cosmetic formulation, **a rule of thumb is that HSP distances of 4 or less indicate high similarity, while distances above 8 indicate high dissimilarity.**

An Example Let's work through an example problem. This table is populated with the HSPs for four common solvents.

Solvent	δD	δP	δH
Acetone	15.5	10.4	7
Ethyl Acetate	15.8	5.3	7.2
Ethanol	15.8	8.8	19.4
Water	15.5	16	42.3

If a formulator wanted to substitute Ethanol for another solvent in the table, they could calculate the distance measure to find a suitable substitute.

HSP distances to Ethanol

Solvent	δD	δP	δH	Euclidean Distance to Ethyl Acetate
Acetone	15.5	10.4	7.0	5.01
Ethanol	15.8	8.8	19.4	12.70
Water	15.5	16.0	42.3	38.39

The resultant distances table indicates that Acetone would be the most viable substitute among these three chemicals for Ethyl Acetate on a molecular similarity level.

Sustainable Substitutions

After we ensure that our clients have a suitable molecular match, we can inspect the total environmental impact of the molecule to see if it is less than the one it is substituting, and therefore a suitable, and sustainable alternative.

Environmental Impacts of Acetone vs Ethyl Acetate

Impact Category	Value (Acetone)	Value (Ethyl Acetate)
Climate change	2.4341903	3.1789447
Ozone depletion	1.37576e-09	3.53484e-07
Ionising radiation, HH	0.000386295	0.17663701
Photochemical ozone formation, HH	0.008964298	0.013218852
Respiratory inorganics	1.12231e-07	1.68314e-07
Non-cancer human health effects	5.00642e-09	4.96986e-08
Cancer human health effects	2.44922e-10	1.55905e-09
Acidification terrestrial and freshwater	0.012431269	0.017753221
Eutrophication freshwater	0.000154503	0.001190226
Eutrophication marine	0.001799067	0.002927433
Eutrophication terrestrial	0.019644304	0.031039858
Ecotoxicity freshwater	3.7746155	86.419014
Land use	0.034853544	11.503473
Water scarcity	1.3279614	1.6418759
Resource use, energy carriers	61.920518	70.013799
Resource use, mineral and metals	5.08089e-07	3.66599e-05

Here we see that Acetone is better on every environmental impact metric when compared with Ethyl Acetate, and would be a potentially suitable, and more sustainable substitute.

This method can be combined with supplier specific data to provide tailored advisory per each of our partners. With information on a formulator's participating laboratories, environmental impact's and chemicals for sale, Fairglow can tailor recommendations based on that precise data.

Conclusion

Fairglow enables anyone to measure, understand, and reduce the environmental impact of their cosmetic products. Whether you are a cosmetic brand, retailer or laboratory, Fairglow has the technology and expertise to help you today.

Visit our website and get in touch with us!