ISSN 1993-890X
www.led-professional.com

LED professional

BY LUGER RESEARCH

Review

LpR 102

Mar/Apr 2024

LIGHT + BUILDING POST-SHOW REPORTS AND INTERVIEWS

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Eco-Innovation in Lighting: LCA-CALC Leads the Way in Sustainable Lighting Solutions

Tiphaine TREINS, Founder and Head of Temeloy

LCA-CALC was born out of Tiphaine Treins's, founder and CEO of the innovative eco-lighting studio Temeloy, frustrations with the inability to obtain reliable, scientific, and usable eco-design metrics at a reasonable cost, combined with her desire to innovate and move the lighting industry markedly closer towards a more environmentally conscious future.

Ms Treins partnered with the International Reference Center for Life Cycle Assessment and Sustainable Transition (CIRAIG) to build LCA-CALC. CIRAIG is a cutting-edge life cycle assessment research center that develops metrics necessary for a transition to an eco-friendly society and is affiliated with Polytechnique Montreal. This made the partnership an obvious and fruitful fit. Using CIRAIG's expertise, Treins created the first online, accessible and affordable tool to calculate the environmental footprint of all LED lighting fittings (exterior, interior, decorative fittings) using life cycle assessment (LCA).

LCA=CALC
SMART ECO-LIGHTING METRICS

https://lca-calc.com/

LCA is governed by the ISO 14040-44 standards. The general methodology of LCA is first the quantification of all the exchanges with the environment (resource inputs and emissions to air, water and soil) of all the activities related to the use of a product, covering all its life cycle stages: the initial extraction and transformation of natural resources, the manufacturing of the product, its distribution, use and end-of-life **Figure 1**. The quantified exchanges are then converted into relevant environmental indicator results, such as the *climate change* indicator in kg of CO_2 equivalents.

There are four phases to an LCA study:

1. The goal and scope definition, where the recipe, i.e., the what and the how, for the study is specified;
2. The life cycle inventory (LCI) analysis, where data about the environmental exchanges of the considered activities are collected and related to a reference unit;
3. The life cycle impact assessment (LCIA), where the quantified environmental exchanges are converted into the relevant environmental indicator units; and
4. The interpretation of the results, where their environmental significance is assessed and recommendations and conclusions are drawn.

Two modes are available in LCA-CALC, the first is more focused on eco-design and identifying the main activities/components/-materials contributing to a lighting fitting environmental footprint and thus guiding efforts to improve it, the second is aimed at producing an environmental product declaration (EPD) for a lighting fitting. An EPD is a communication tool used to provide the environmental footprint, i.e., a series of relevant environmental indicator results calculated through LCA, of a product to a target audience. EPD can then be used to compare the environmental performance of similar products.

As multiple methodological choices have to be made during an LCA, e.g., the systems boundaries (specifying the considered activities), the calculation reference unit, the set of environmental indicators, for EPD to be comparable the LCA methodology needs to be consistently applied to each product, i.e., the LCA recipe and the elements presented in the EPD need to be the same. Product category rules (PCR) are used to specify the recipe for the LCA serving as the basis for the EPD of products in a same category. EPD and PCR are governed by the ISO 14025 standard, which requires EPD program operators to manage the publication of PCR and EPD. A PCR for lighting fittings is available through the French PEP Ecopassport EPD program operator, the PSR0014, whose second edition was published in 2023 and is followed by the EPD mode in LCA-CALC. As of now, no PCR is available for the North American market but a think tank is working of developing one in the near future.

Several LCIA methods are available to LCA practitioners, LCA-CALC includes two of the most recently developed ones: Environmental Footprint (version 3.1) and IMPACT World+ (v2.01). The American TRACI (v4.2) method will be added in the near future. Each method differs in the set of environmental indicators it provides, and the environmental models used to calculate their results. The EF v3.1 method, specified in the PSR0014 ed. 2, provides a set of 16 of what are commonly called midpoint indicators which focus on specific issues like *climate change*, stratospheric ozone layer depletion or freshwater eutrophication; results are generally expressed in units of reference substance equivalents (kg CO_2 eq. for the *climate change* indicator). IMPACT World+ v2.0.1 provides three levels of indicators: midpoints, damages and areas of protection (AoP). The included midpoint indicators are very similar to and provide the same level of environmental coverage as the ones in EF v3.1. Those are, however, translated

into damages on the areas of protection (AoP) *Human health and Ecosystem quality*. The AoP indicators aggregate several relevant midpoints, thus reducing the number of indicators to be considered in the assessment and facilitating the interpretation of the environmental footprint. The first accounts for the potential impacts on human health from greenhouse gases, toxic substances (carcinogenic and non-carcinogenic), those that lead to respiratory problems, that generate ionizing radiations or photochemical oxidant (smog) and that deplete the stratospheric ozone layer and water availability and is expressed in DALY (*disability-adjusted life years*). The second accounts for the potential impacts on ecosystem quality, or biodiversity, from *climate change*, acidification, eutrophication, freshwater ecotoxicity, land use and water availability and is expressed as the fraction of species that will potentially disappear (potentially disappeared fraction – PDF) in a given area and over a certain time period (PDF*m²*year). LCA-CALC provides results for the *Human health and Ecosystem quality* AoP and the Fossil and nuclear energy use and Mineral resources use midpoint indicators.

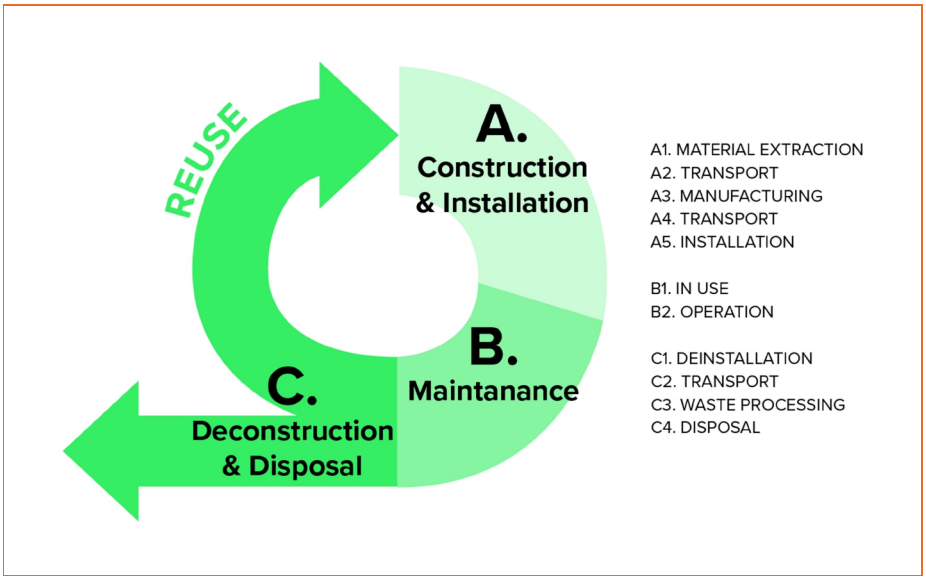

Figure 1: Life Cycle Assessment (LCA) methodology is a comprehensive approach used to assess all the environmental impacts associated with all the stages of a product's life from its beginning to its end.

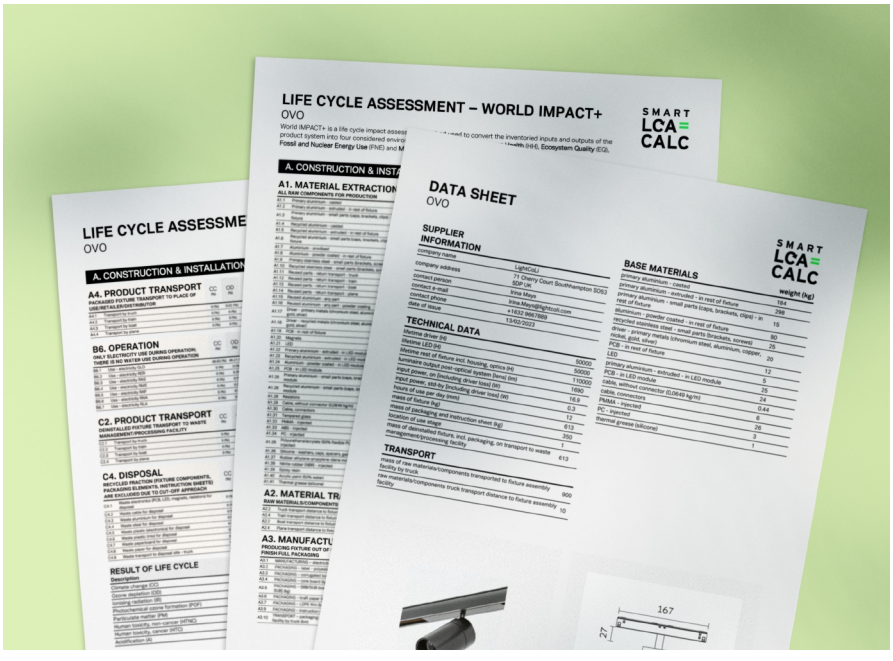

Figure 2: LCA report calculated from the calculator helps understand and evaluate the severity and significance of the potential environmental impacts.

In order to model the life cycle of the lighting fittings, the user enters data into the online platform. Required data includes the list of materials and their respective amounts, manufacturing, distribution, use and end-of-life information. Light output, driver power, fitting and components lifetime and electricity consumption during use and stand-by data are also required. All activities directly related to the lighting fitting make up the foreground system, essentially the manufacturing, distribution and use life cycle stages, while all other activities make up the background system: materials and components production, energy (electricity) production, transports and waste treatment. As specific data cannot be collected for all background activities due to time and cost constraints, those are modeled using generic datasets taken from life cycle inventory (LCI) databases. LCA-CALC makes use of datasets included in the widely used and annually updated LCI database ecoinvent, version 3.9.1 (2023) using the *Cut-off* system model. This database provides global coverage for the included activities while presenting regionally differentiated datasets for several activities. The global average context was considered in LCA-CALC but for the electricity generation during the use stage for which several regional and national grid-mixes are available. A generic dataset is available for the production of LED but the user can also adapt it to better represent its own LED design when they have the information.

LCA-CALC can also model lighting fittings designed with a circular economy model. The tool can consider the reuse of components, by including the transport and treatment of the previous used fitting, and includes datasets on recycled materials. For the latter, the approach used is consistent with the ecoinvent *Cut-off* system model, which considers that all burdens associated with the collection, sorting and recycling of the pre-recycling material, i.e., waste material, are allocated to the recycled material and the life cycle which uses it.

Once the lighting fitting life cycle is modelled by entering all required data for each life cycle stage, LCA-CALC relates all the entered data to the calculation reference unit ("providing 1000 lumens for 35000 hours" or "providing the lumen output of the lighting fitting over its lifetime") and provides the absolute and relative results for the set of indicators of either included LCIA methods (EF 3.1 and IMPACT World+ 2.0.1). The first includes the generally accepted indicator for carbon footprints in kg CO_2 eq. (split into fossil, non-fossil and

land transformation sub-indicators). The tool also generates pre-filled LCA report and EPD templates that will facilitate their preparation for their submittal to the verification process leading to the publication of the EPD by a program operator recognizing the PSR0014 ed. 2 PCR for lighting fittings.

As was previously mentioned, EPD of lighting fittings can only be compared if they not only follow the same recipe, i.e., PCR, but if the same choices are made concerning the few elements for which PCR leave some flexibility to the practitioner conducting the underlying LCA, e.g., use stage electricity grid-mix, LCI database used to model the background activities. Moreover, several characteristics of lighting fittings are not considered in the available PCR for this product category, e.g., CCT, CRI, typology, which could affect the environmental performance of those products. More generally, the environmental footprint of a lighting fitting should not be the only criteria used to judge its overall quality: design and technical criteria should also be considered. The Lighting for Good initiative, another brainchild of Ms Tiphaine Treins, aims to create a market benchmark for lighting fittings that would account for all those aspects. In 2024, it will launch the first eco-lighting awards based on life cycle assessment (https://lightingforgood.org/awards/).

LCA-CALC is the first tool of its kind for the lighting industry. Other attempts, such as the Chartered Institution of Building Services Engineers (CIBSE) Technical Memorandum 66 (TM66), have been made to create environmental metrics for lighting. Whereas TM66 only provides recommendations for design and manufacture of circular products, LCA-CALC is a widely applicable and in-depth life cycle quantitative assessment tool for all LED lighting fittings, new and reused, circular or not.

LCA-CALC is user-friendly, flexible, accessible and affordable for lighting manufacturers and designers who wish to prioritize transparent and eco-friendly manufacturing and design. ■

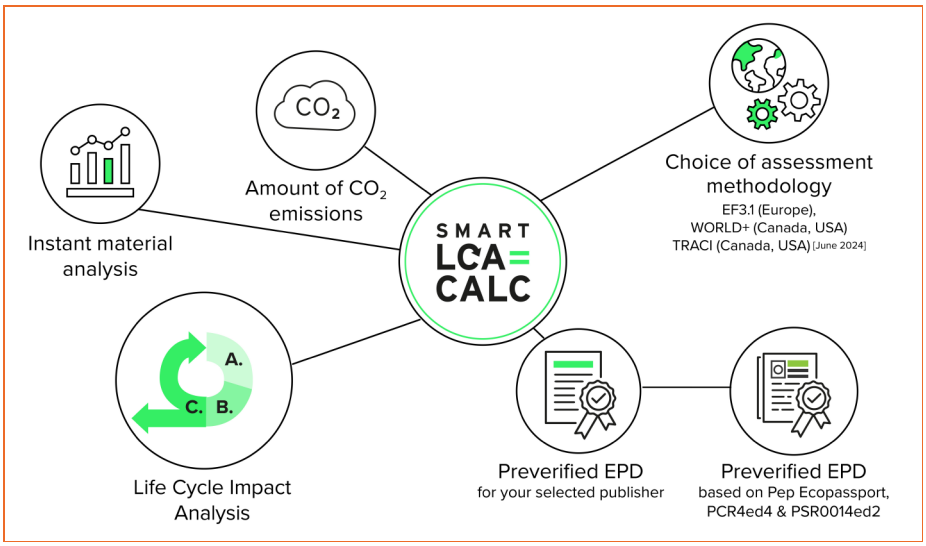

Figure 3: LCA-CALC encompasses an extensive array of eco-lighting metrics. After filling in the Life Cycle Inventory (LCI) in the calculator, users can extract a diverse range of information and reports. They have the option to concentrate on CO_2 emissions, utilise the calculations to refine and minimise the design of their luminaires or generate pre-verified Environmental Product Declarations (EPDs) that include the LCA report.

Tiphaine Treins, founder and principal of Temeloy Eco-lighting Innovator, is a leading -edge lighting designer who integrates state-of-the art technology with innovation, beauty, creativity and sustainability. Treins, a French national, is currently based in London. Her unique lighting signature can be found on homes, luxury boutiques, superyachts, parks, museums, exhibitions and events all around Europe.

Treins founded Temeloy Lighting in 2009 and has since been involved with a roster of diverse clients and demanding projects. At Temeloy, Treins focuses on improving, evolving and innovating lighting design. Temeloy endeavours to create excitement with original lighting concepts that elicit an emotional and visceral response. To that end, Treins has developed a platform of "augmented architecture". In short, she ensures architecture and lighting solutions interact with their surroundings. Once that occurs, any given space will, no doubt, create a richer experience to the passer by. A good example is the Grande Epicerie's living façade in Paris where the plants evolve and grow with the seasons. Treins also implemented augmented architecture at the 2012 "Renault Car Show" and with the exceptional dome at the Elephant Paname Art Center.
Treins feels all big picture ideas require a holistic approach. Key to this is the ability to listen, and communicate, before implementing your ideas. Treins also feels it is of paramount importance to develop strong relationships, respect and trust with the people with whom you are working.

Tiphaine TREINS.

In 2018, together with Nicolas Martin, LVMH lighting manager and director of environment, Treins created a "think tank" and a program called Lighting for Good with the object of establishing an "eco gold standard" for suppliers of lighting fixtures. Eco-design, eco-lighting, and sustainability is something that Treins not only encourages but also strives for with all of her work.

LCA-CALC represents a significant step forward in her path of eco-innovator, demonstrating a commitment that has demanded patience, resilience, and determination.

Treins is committed to creating and delivering outstanding results to each and every project that she manages. Her passion and dedication are evident in her work. She puts her all into creating something extraordinary. And for Treins, Eco-lighting innovation brings research and intelligence to the process of designing with light.

The first Life Cycle Assessment calculator for the lighting industry

LCA=CALC
SMART ECO-LIGHTING METRICS

Reducing costs and complexity on your path to sustainability

Assess life cycle impact analysis (LCA) of your luminaire

Receive instant material analysis

Calculate the CO_2 emissions of your luminaire

Create your:
Pre-verified EPD
for your selected publisher

Pre-verified EPD
based on PEP Ecopassport
PCR4ed4 & PSR0014ed2

Choose your assessment methodology
EF3.1 / World+ / Tracy (01/2024)

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