LIFE CYCLE ASSESSMENTS

ESTABLISHING THE ENVIRONMENTAL IMPACT OF CHEMICAL PRODUCTS

FOREWORD

In an era where sustainability is no longer a mere buzzword but a crucial imperative, industries worldwide are facing the pressing need to reassess their processes, products and impacts on the environment.

With a reported 96% of manufactured goods relying on some form of chemical process, the chemical industry stands as a pivotal player, wielding significant influence over global supply chains and environmental footprints.[1]

The adoption of Life Cycle Assessments (LCAs) has emerged as a vital tool in this journey towards sustainability, offering a comprehensive framework to evaluate the environmental impacts of products and processes across their entire lifecycle. From resource extraction and manufacturing to product use and disposal, LCAs provide invaluable insights into the cradle-to-grave environmental implications of chemical products.

For the chemical industry, embracing LCAs represents more than just a nod towards environmental responsibility; it signifies a profound commitment to the green transition.

With the world's eyes increasingly focused on reducing carbon footprints, minimising waste, and conserving resources, the chemical sector has a unique opportunity to lead by example.

By integrating LCAs into their operations, chemical companies can proactively identify areas for improvement, optimise resource utilisation and innovate towards more sustainable solutions.

Nonetheless, navigating the intricacies of LCAs can be daunting, especially for those unfamiliar with the methodology or its application within the chemical industry.

This guide aims to demystify LCAs, offering practical insights, best practice, and case studies from the chemical industry itself. This guidance will enable stakeholders to gain a deeper understanding of the significance of LCAs and the prominent role they have to play in driving sustainable innovation.

We hope you and your business find this a useful resource and do please get in touch with any queries, suggestions or feedback.

With the adoption of LCAs in the chemical sector we aim to enhance product sustainability, reduce environmental impacts, and forge a path towards a more resilient future.

Steve Elliott
Chief Executive of the Chemical Industries Association

1 ISSD (2019), ICCA Report Highlights Chemical Industry's Contribution to Global Economy, available at: SDG Knowledge Hub | ISSD (Accessed 9 May 2024).

WHAT IS A LIFE CYCLE ASSESSMENT?

A Life Cycle Assessment (LCA) considers the environmental impacts of product systems over their defined life cycles, enabling key hotspots to be identified.

The insights and understanding gained from an environmental LCA allow organisations to make decisions on managing the environmental impacts of their product or process.

The principles of LCA and the framework for carrying one out are defined in ISO 14040; which defines LCA as: the **"compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle"**.

> **REGULATORY FRAMEWORKS PROVIDE A DIRECT REQUIREMENT FOR ORGANISATIONS TO TAKE POSITIVE ACTION TOWARDS THEIR SUSTAINABILITY AGENDA.**

Figure 1. The benefits of using a Life Cycle Assessment include:

REGULATORY REQUIREMENTS

- Use in sustainability reporting
- Encourage regular data gathering

INFORM DECISION MAKING

- Identify hotspots
- Internal product development
- Help in procurement
- Benchmark against competitors
- Avoid burden shifting

COMMUNICATE PRODUCT BENEFITS

- Communicate environmental impact
- Attract customers
- Gain competitive advantage
- Demonstrate active improvement

WHY USE LCA?

Regulatory frameworks provide a direct requirement for organisations to take positive action towards their sustainability agenda. In some cases, organisations must adhere to legal requirements or face penalties – potentially with financial implications.

With an ever-increasing focus on sustainability from across society, showing a commitment to climate change is becoming a minimum requirement in the competitive market, the loss of a customer base resulting in a less competitive business. An avoidable issue when organisations seek to proactively engage with a sustainability strategy.

Regulatory requirements

A number of explicit environmental regulatory requirements will impact chemical products.

These include The European Commission's Chemical Strategy for Sustainability; the Ecodesign for Sustainable Products Regulation (ESPR) and, the introduction of digital product passports (DPP) along with voluntary frameworks such as Safe and Sustainable by Design (SSbD).

Numerous forthcoming regulations and frameworks aim to better protect citizens and the environment from harmful chemicals and will require insight into a product's component materials and its environmental impact.

Inform decision making

LCA is a decision-making tool. It provides insights into product systems, which in turn gives organisations the capability to adjust aspects of the system within their control and encourage improvements across the whole value chain, to potentially improve the environmental performance of their products.

A further benefit is that LCA helps avoid 'carbon tunnel vision' and provides a more holistic view of the sustainability of a product. LCA can be used to assess the potential environmental impacts of product systems over a wide range of environmental indicators preventing the potential for 'burden shifting' – the outcome of decreasing one particular environmental impact at the expense of increasing another, inadvertently or otherwise.

Communicate product benefits

The outcomes of an LCA can be communicated to stakeholders and customers where the growing focus on sustainability and environmental concern can be seen to influence purchasing decisions. Potentially providing competitive advantage over alternative products with higher impacts, the output of a robust LCA can be used as evidence to support sustainability claims.

Digital Product Passports (DPP)

Seeking to enable climate action and enhanced circularity in the EU, the European Ecodesign for Sustainable Products Regulation (ESPR) introduces the concept of a 'digital product passport' to store and share information throughout a product's life cycle. The product passport system would provide industry stakeholders, businesses, public authorities, and consumers with a better understanding of the materials used in the product as well as their environmental impact.

Environmental Product Declaration (EPD)

An Environmental Product Declaration (EPD) is an independently verified declaration that quantifies environmental information on the life cycle of a product performed in accordance with specific standards and rules. EPDs are primarily intended for business-to-business communication of environmental performance but may also be used for marketing advantages, or for organisations to demonstrate a commitment to the environment to customers through transparent disclosure.

United Nations Sustainable Development Goals (SDGs)

The results from an LCA can also support organisations with sustainability reporting and supplements data gathering efforts benefiting organisations with sustainability strategies connected to the United Nations Sustainable Development Goals.

Carbon emissions and Scope 3

The results from an LCA relating to climate change or Global Warming Potential may be used to support Scope 3 reporting according to the Greenhouse Gas Protocol and can contribute towards the reporting required for the Science Based Target initiative (SBTi).

Social impact

Used to model the potential social impacts associated with the life cycle of a product system, social LCA (S-LCA) can be quantitative, semi-quantitative or qualitative and complements environmental LCA. S-LCA is useful for organisations wishing to investigate potential ethical vulnerabilities within their supply chain. Again, this can be used to align with an organisation's UN SDG strategy and support an organisation's supply chain due diligence activity.

Holistic product sustainability

Whilst the historical focus on product sustainability has been one of quantifying and reporting on carbon or greenhouse gas emissions (i.e., carbon foot printing) the landscape is fast-evolving. Many organisations are now looking to quantify and report on multiple aspects of their product's impacts, which life cycle assessments are designed for.

Figure 2. The United Nations Sustainable Development Goals

SUPPORTING SCIENCE BASED TARGETS

Science Based Targets are goals for reducing greenhouse gas emissions that are informed by the latest climate science and aligned with the Paris Agreement, aiming to limit global warming to 1.5°C.

With a defined baseline, a target date, and a reduction pathway, the Science Based Targets are different from other sustainability targets. This is because they focus purely on greenhouse gas emission reduction and are based on the emissions budget which calculates the permissible level of emissions while maintaining the temperature limit.

The SBTi is a corporate climate action organisation that enables companies worldwide to set and achieve targets in order to combat the climate crisis.

SCIENCE BASED TARGETS

DRIVING AMBITIOUS CORPORATE CLIMATE ACTION

What is the difference between a Product Carbon Footprint (PCF) and LCA?

A carbon footprint measures the total greenhouse gas emissions related to a product over its life cycle. The 'Together for Sustainability Product Carbon Footprint Guideline of the Chemical Industry' is industry-specific guidance on calculating PCFs for chemical products. Compliant with ISO 14067 and GHG Protocol accounting standards, it is based on life cycle assessment methodologies but focuses on the single issue of greenhouse gas emissions.

> **AN LCA GOES BEYOND JUST CARBON EMISSIONS AND PROVIDES DEEPER INSIGHT INTO A PRODUCT'S ENVIRONMENTAL IMPACT ACROSS A RANGE OF IMPACT CATEGORIES.**

With more accurate data obtained, corporate organisations will have a clearer picture of their upstream supply chain emissions. This enables collaboration with suppliers and the wider supply chain through sharing accurate PCF data, meaning areas for improvement can be identified and collaborative solutions can be sought to deliver reduced emissions measurements.

GREENWASHING

Greenwashing is the term given to a company falsely presenting their products as being environmentally conscious. 'Greenwashed' claims are often unsubstantiated and aim to capitalise on sustainability motivations of consumers using environmental imagery or misleading labelling.

Beyond product claims, organisations can also be accused of greenwashing corporate sustainability achievements and 'carbon washing', aiming to minimise the perceived environmental impact of its operations.

Hitting the headlines, litigation cases on the grounds of misleading promotional messages, or greenwashing, have impacted organisations with both legal costs and penalties.

By fully interrogating a product and its component parts through a life cycle assessment, organisations can gain clarity over the true impact while generating evidence to inform and support sustainability claims.

The Sustainability Disclosure Requirements (SDR) and Investment Labels regulation includes an anti-greenwashing rule to reinforce that sustainability-related claims must be fair, clear and not misleading.

GREENHUSHING

The term 'greenhushing' has been coined to refer to companies purposely keeping quiet about their sustainability goals, even if the organisation has objectives that are well-intentioned or plausible due to fear of being labelled 'greenwashers'.

The Financial Conduct Authority (FCA) is introducing a number of measures to support consumers in navigating the market for sustainable investment products.

Product Environmental Footprint

With the aim of mitigating against the challenges relating to the inconsistency of LCA approaches, the European Commission has introduced the Product Environmental Footprint (PEF) methodology.

Key features of PEF:

- Specifies 16 impact categories to use.
- Provides Category Rules for products (PEF-CRs).
- Mandates which life cycle stages to include.
- Provides a database of approved secondary datasets to use.
- Mandates a new end of life methodology, the Circular Footprint Formula (CFF).
- Dictates how quality control and interpretation should be performed.

PEF is likely to become the key methodology for assessing the impact of products intended for sale within the European Union. At present, the list of Category Rules is not exhaustive and some products do not have a corresponding PEF-CR, meaning that for some products an LCA cannot be PEF compliant.

Ricardo recommends that LCA studies should attempt to align with PEF where compliance is not possible, and that companies trading within the EU should start to understand the PEF requirements.

Figure 3. The 16 impact categories of the European Commission's Product Environmental Footprint methodology

KEY REGULATORY FRAMEWORKS

- European Commission’s Green Deal
- Chemical Strategy for Sustainability
- Ecodesign for Sustainable Products Regulation (ESPR)
- Digital Product Passports (DPP)
- Safe & Sustainable by Design (SSbD) framework is part of the EU’s wider Chemicals Strategy for Sustainability (CSS) (EC2020) policy
- UK CMA’s Green Claims Code
- US Federal Trade Commission’s Green Guides
- EU Green Claims Directive

THE PRODUCT LIFE CYCLE

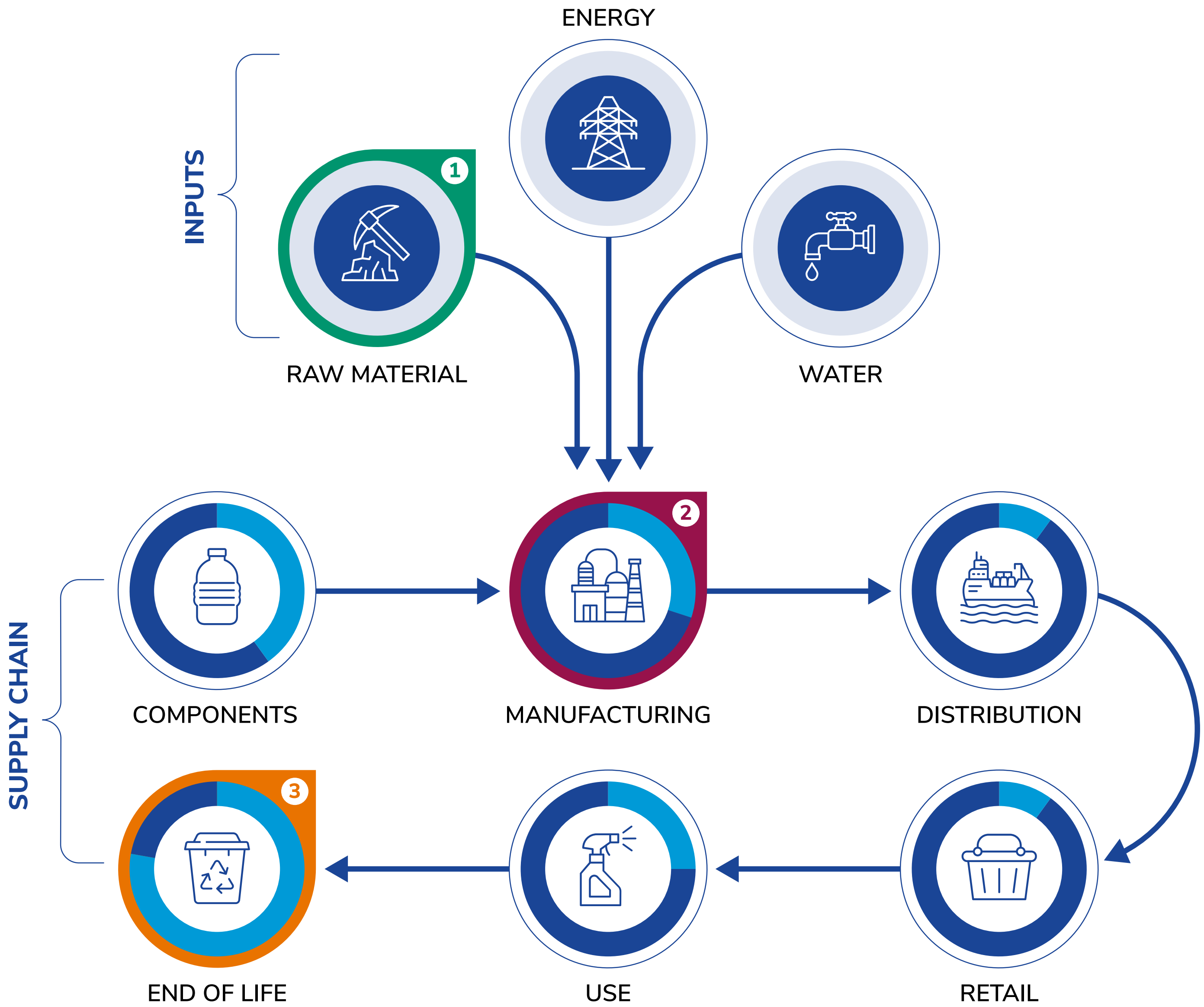
By covering a wide range of environmental impacts and considering both direct and indirect effects, LCAs offer invaluable insights for improving sustainability.

Figure 4. Product life cycle

Indicative environmental effect of each stage in the supply chain

ROUTES TO REDUCTION
(See following page for detail)

1. BIO-BASED RAW MATERIALS
2. CARBON CAPTURE AND USE
3. PRODUCT CIRCULARITY



→ ROUTES TO IMPACT REDUCTION

1 BIO-BASED RAW MATERIALS

Bio-based chemicals derived from renewable feedstocks, such as agricultural residues, or algae can reduce reliance on fossil resources. Agricultural residues, for example, can be converted into bioplastics and bio-based chemicals can be co-produced alongside biofuels in biorefineries which maximise resource utilisation.

Compared with fossil-based materials, bio-based materials may have lower environmental impacts. Switching to or developing products using bio-derived feedstocks and away from fossil-derived feedstocks may result in a lower environmental impact in categories such as climate change or greenhouse gas emissions, but what might the effect of this switch be on other environmental aspects such as land or water use?

LCA can help to provide a holistic assessment of the potential environmental impact of a product across a broad range of categories. It can also be used to support decision making through the identification and assessment of potential alternative raw materials.

2 CARBON CAPTURE AND USE

Capturing CO_2 at source is another potential route for organisations to reduce their carbon emissions and overall impacts of their products. Carbon capture and storage (CCS) processes intervene before carbon dioxide is released, enabling it to be captured, transported and stored securely.

Carbon capture and utilisation (CCU) is an emerging field for emissions mitigation and seeks to find alternative uses for stored carbon, and the range of products that could be produced is vast. The challenges here are the ability to source cheap, renewable energy to power the chemical process, geographic location, and market demand for the resulting products.

CCU is complex due to the double role of CO_2 as both feedstock and emission. The potential benefits need to be assessed over the entire product life cycle.

3 PRODUCT CIRCULARITY

Product circularity aims to stop waste from being produced by recovering materials for reuse and remanufacturing these into new products.

Products are designed with end of life in mind and kept in use for as long as possible through practices like repair, recycling, and redesign. Circularity, through the use of renewable energy and re-use of materials, can help minimise the impact an organisation's activities have on the depletion of finite resources.

The development of circular products offers organisations resilience and provides wider benefits to businesses, people, and the environment through resource efficiency and responsible design. LCAs can identify where circularity may be achieved as they consider the entire life cycle of a product and provide the opportunity to model interventions, changes or alternatives to traditional materials or methods that could be used.

CONDUCTING AN LCA

Conducting an LCA can be complicated. It requires a defined purpose to the assessment, the product system to be established, the system boundary and methodological approach to be defined.

Decisions to determine whether you assess only the impact of the production i.e. considering the inflows (e.g. raw materials, energy, water) and outflows (e.g. product, waste, emissions) which correspond to the product itself (cradle-to-gate) or the impact of the product over its entire life cycle (cradle-to-grave) need to be made.

The LCA process can be broken down into four components:

- **1. Goal and Scope Definition** – Establish the purpose of the assessment and identify the system boundary, the unit of the product under assessment, assumptions and limitations and the impact categories to be considered.
- **2. Life Cycle Inventory Analysis** – Create an inventory of flows between the system and the environment and quantify the inputs and outputs.
- **3. Life Cycle Impact Assessment** – Assess the potential human and ecological effects of material, water, energy, usage and emissions and convert flows into equivalent units.
- **4. Interpretation** – Summarise the results of the inventory analysis and impact assessment.

→ ISO COMPLIANCE

To be ISO compliant, LCA studies must be conducted in accordance with the specific requirements set out in ISO 14044:2006 and follow the methodology stated in ISO 14040:2006.

The LCA framework as set out in the relevant ISO standards has its limitations. It is possible for different conclusions to be drawn from similar product system studies depending on the adopted assumptions and exclusions. Conflicting conclusions drawn about two different studies may both be correct which presents a problem for organisations seeking concrete, transparent information about their products.

If an organisation wishes to share the results of an LCA publicly (including with customers) and claim ISO compliance, a third-party report is required. To enhance the credibility of LCA results and conclusions, it is considered best practice to undergo critical review by a third-party (i.e., someone that did not carry out the LCA).

If an organisation wishes to make public comparative assertions regarding the superiority or equivalence of one product versus a competing product that performs the same function, then a critical review by a panel of experts is mandatory according to the ISO standards.

> **TO SHARE THE RESULTS OF AN LCA PUBLICLY AND CLAIM ISO COMPLIANCE, OR IF THE LCA CONTAINS COMPARATIVE ASSERTIONS ON PERFORMANCE, A CRITICAL REVIEW BY A PANEL IS REQUIRED.**

Timeline to LCA

The cost of LCA can be high. Resource and time hungry, and often taking months to complete, LCA requires commitment from subject matter experts to ensure high quality results.

For businesses which generate multiple products this approach can be cost prohibitive. What's more, the value of LCA assessment can be time limited due to the changing manufacturing environment, so development of LCA tools to allow for inhouse calculation can be of benefit.

Allocation of impacts

Allocation is dividing the input or output flows of a process between the product system that is under study and other product systems. It is key to deciding how emissions are allocated at each stage of a product's life and necessary when a product or process has multiple outputs or serves multiple purposes. When modelling multifunctional processes and recycling or end-of-life processes as are common in the chemicals sector, there are a number of approaches that can be taken.

Common allocation approaches used in LCA:

- **Consequential approach** – the first in the hierarchy prescribed by ISO14044 and ISO14067. Also called the substitution approach, system expansion, or avoiding allocation. Requires assumptions around avoided burdens to be made.
- **Attributional approach** – often done using physical allocation, economic allocation, or allocation at the point of substitution (APOS) to assign a certain environmental impact to the product. For multi-functional processes, this requires classification of outputs as waste, recyclable material, or marketable co-products and to determine an allocation factor for the marketable products.
- **Physical allocation** – assigns an allocation factor using physical characteristics e.g., mass, volume, energy content, and energy input associated with each co-product (or by-product).
- **Economic allocation** – where physical allocation is considered unfair for users of the lower-valued by-products the price of the product and co- or by-products to calculate the allocation factors to be used.
- **Allocation at the point of substitution (APOS)** – where responsibility over wastes (burdens) is shared between producers and subsequent users benefiting from the treatment processes by using valuable products generated in these.
- **Recycled content or cut-off approach** – allocates burdens at the point where a product is sold and applies a cut-off at the point the recyclable material leaves the product system.
- **Circular Footprint Formula (CFF)** – the method published by the European Commission in its PEF methodology. Integrates aspects of different end-of-life allocation approaches, in combination with material and market-specific characteristics (e.g., material degradation and recycling rates). Considers the circularity of materials and products and accounts for the proportion of recycled content and the environmental impact of recycling.

CASE STUDY

DEMONSTRATING AVOIDED EMISSIONS WITH LIFE CYCLE ASSESSMENT

CRODA

Ricardo has been working with Croda International Plc to empower better understanding and inform actions to reduce the environmental impact of its products using a bespoke life cycle assessment (LCA) tool developed by Ricardo.

Croda International Plc is a global chemicals manufacturer that supplies speciality ingredients to a number of sectors, including the consumer care and life sciences markets. Sustainability is a core theme for Croda and it is committed to becoming Climate, Land and People positive by 2030.

Challenge

As part of its ongoing sustainability strategy, Croda has set a target to complete 100 cradle-to-grave LCAs on its products by 2030. These LCAs help Croda to understand the environmental impact of its products right from the sourcing of raw materials through manufacture and use, to recycling and/or final disposal.

LCAs identify environmental impact 'hotspots' along the product value chain allowing Croda to see where the most effective changes can be made to mitigate emissions. The LCAs also highlight where Croda's products are already offering benefits (such as avoided emissions) which extend down the value chain, benefiting Croda's customers and providing the evidence behind sustainability claims.

Our approach

Using the LCA tool developed by Ricardo, Croda can robustly demonstrate how its products are already contributing to reduced emissions throughout the value chain and also highlight where further mitigating action would be most effective for future product development. The flexible modelling functionality of the tool enables Croda to develop evidence on the relative differences between various configurations and options for its products as used by its customers.

Ricardo's support to Croda included:

- Initial workshops to help Croda's leadership teams better understand what LCAs are, their benefits and how to maximise the opportunities they present.
- Development of a robust bespoke LCA tool that can be easily used and applied across Croda's extensive product range.
- A pilot study on Croda's fabric conditioner additive, Coltide Radiance.
- Extensive training and continued support of Croda's in-house team on use of the bespoke tool, as well as LCA methodology and application, enabling them to carry out their own robust LCAs and model product use scenarios.

Results

Before working with Ricardo, Croda had carried out some cradle-to-gate carbon footprints of its products. Now, its sustainability team is equipped with a purpose-built tool and are confident in the skills to analyse the whole value chain for its products, identifying hotspots where mitigation is required, modelling product scenarios for maximum impact and ensuring it has robust data to underpin the sustainability claims of its products.

"The flexible LCA tool Ricardo created for us will enable us to model any product from our range and simulate different scenarios to help our product development process. Having a custom LCA tool to run various analyses, as broad or detailed as we need, is really useful and will help us support our customers with their sustainability data requirements and in understanding the benefits of Croda's ingredients.

Ricardo's in-house training and support throughout the project has been invaluable and we are looking forward to working with them on the next stage."

Julia Creasey
Group Sustainability Director, Croda

SUMMARY

Life cycle assessments are complex, requiring experience and knowledge of the processes and frameworks they support to ensure effective and reliable assessment – and correct interpretation of results. Businesses can gain insight to current environmental impacts which can be used to inform development in alignment with the global sustainability agenda. Consumers and regulatory bodies are aligned in the direction of travel, and demand for visible change is increasing rapidly. Minimising risk and the unintended consequences of uninformed change is essential.

Supporting your organisation to maximise the value of life cycle assessment

- **Goal and scope** – We provide guidance on how to get the best out of the process, and identify the key requirements and challenges faced by your organisation.
- **Inventory** – A review of your entire product portfolio to identify families of products, and provide a strategic approach to supporting opportunities for improvements to your portfolio's environmental impact.
- **Assessment** – Undertaking the life cycle assessment by collating, validating, and processing the data or developing bespoke LCA tools for organisations to support internal LCA capability.
- **Interpretation** – The vital step to obtain insight to the factors affecting environmental impacts and their scale, our experts consider the highest priority impacts to help you focus on the sustainability indicators where improvements are most needed.
- **Responding to the assessment** – Our team can provide guidance around the 'quick win' tactical changes that can make efficient large-scale reductions in the priority impact categories, such as decarbonising energy sources, or finding local suppliers.
- **Strategic sustainability support** – Working with your organisation to provide solutions to support your organisational strategy. Our in-house specialists can be called upon to advise and guide on ESG strategy, Net Zero pathways, Scope 3 emissions, renewable energy solutions, corporate sustainability reporting, circular economy, sustainable packaging and sustainable procurement.

Contact us to discuss how you want to use LCAs to support your organisation's objectives:

RICARDO

info@ricardo.com

www.ricardo.com/sustainableproducts

cia

enquiries@cia.org.uk

www.cia.org.uk