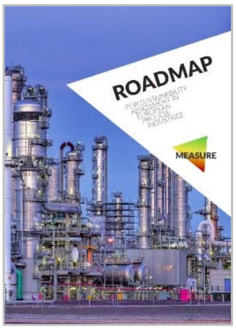
Background document

supplementing the

“Roadmap for

Sustainability Assessment in

European Process Industries”



Sector A:

Chemistry and Fast-moving Consumer Goods

Authors:

A. Manent[1], E. Rother[1], D. Schowanek[2], G. Vanhoof[2], P. Weyell[3], D. Kralisch[3]

1 Evonik Technology & Infrastructure GmbH, Life Cycle Management

2 Procter & Gamble Services Company NV, Global Product Stewardship

3 Friedrich-Schiller-University Jena, Institute of Pharmacy, Department of Pharmaceutical Technology

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1 Introduction

The European Chemical Industry as well as the fast-moving consumer goods (FMCG) industry, linked directly along the value chain, play an important role to meet the challenges of the future as a major enabler of economic, environmental and social progress envisioned in the Europe 2020 strategy (Pellins, Wolters et al. 2011). As a matter of fact, more or less all leading European companies in the sector have installed a company internal sustainability assessment team within the last years in order to react to this new emerging topic. Initiatives such as Responsible Care and companies' Corporate Social Responsibility programmes also show that companies go beyond existing regulations and compliance (CEFIC 2012).

Increase of sustainability awareness, political pressure, limitation in raw material availability, societal demand and market competition have contributed to a reduction of energy intensity (energy input per unit of production) of 47 % compared to 1990 (WBCSD 2014). This significant decrease demonstrates the high efforts already made by the sector to minimize the environmental impact of production.

In addition, workplace safety as one indicator for social aspects of sustainability increased significantly during this time. Today, the chemical industry in Europe is highly regulated in terms of both, products and operations. In consequence, the chemical industry is nearly twice as safe as average European manufacturing industry (WBCSD 2014).

However, the European chemical industries are also actors in global competition. Whereas the world chemicals sales in 2013 were valued at 2,156 billion €, the European Union accounted for only 16.7 % of the total sales (WBCSD 2014). Although the European Chemical Industry is still in a strong position, the worldwide competition is getting fiercer. The European Union (EU) lost its top ranking in terms of sales to China. Today, chemicals sales in Asia are nearly three times larger than the ones of the EU (WBCSD 2014). 10 years ago, the EU was in a much stronger position than today, posting sales in 2003 of 31 % of world chemicals sales in value terms (PlasticsEurope 2011). Although sales have been growing continuously during that period the EU chemicals market share nearly halved in 10 years.

Real innovations fostering an ongoing decoupling of growth from resource depletion, environmental impacts, production costs and a decrease of societal challenges are needed to reverse this trend. In addition, the optimization of existing technologies is important to rejuvenate the success in global competition.

A better sustainability performance has to be proven based on the analysis of the whole product life cycle and should not only be restricted to the production process, or end-of-pipes solution from cradle-to-grave (CEFIC 2012). The sustainability assessment of products or services needs to be based on a life cycle approach in order to obtain a true and holistic picture of the products and prevent problem-shifting. Moreover, all pillars of sustainability (social, environmental and economic) have to be considered and integrated in any decision-making to reach the goal of a competitive European chemical industry.

2 Overview of assessment tools and methods used in the chemistry and FMCG sectors

In the following chapter, a review about the current state of application of sustainability assessment tools and methods in sector A is given. It starts with a brief overview followed by a summary of existing agreements and rules as well as of sector specific topics and critical issues. Then a summary of existing agreements is drawn, followed by a description of sector specific topics and critical issues.

2.1 Short overview of specifics in sustainability assessment in the sector A

The Chemical sector is very diverse and comprises several subsectors (CEFIC 2013) such as the Petrochemical sector (i.e. organic building blocks), the Basic Inorganic (i.e. inorganic building blocks for instance ammonia, chlorine), the Polymer industry with a large variety of end-products, the Specialty Chemicals (i.e. coatings, crop protection, dyes etc.) in which products are designed for a particular customer's need and Consumer Chemicals (i.e. soaps, detergents, perfumes or cosmetics) in which products are sold to end consumers. Resources are also various: fossil, agricultural/renewable and/or mineral resources.

Because of this diversity, the reported data, methods and tools may differ somewhat from the vantage point in the supply chain. Nevertheless, some general trends can be observed and needs identified, that can lead to good practice recommendations for the whole sector that contributes 527 billion € to the EU economy (WBCSD 2014).

The Chemical sector has a number of specificities as compared to other sectors:

- Depending on the step in the value chain, cradle-to-gate studies (chemistry) or cradle-to-grave studies (consumer goods) are conducted more often. Especially in the chemical sector, the analysis is mostly performed only for cradle-to-gate, which does not include the consideration of the functionality of products. The use-phases might actually be very different (for example for plastic or personal care ingredients).

Environmental Product Declarations (EPD type I and II) are accepted as a standardized and Life Cycle Assessment (LCA) based tool to communicate the environmental performance of product. They are intensively used in the chemical sector to communicate the Cradle-to-Gate impacts of products while the use-phase is not investigated. However, main target industry is construction.

- The debate about the impact of fossil versus renewable raw materials is becoming an area of massive interest, accompanied by many internal and external studies. Methods for better assessing bio-based materials are consequently highly relevant in the sector.

- Human and environmental toxicity are, given the nature of materials produced and traded in the sector, often very important topics. The Chemical sector has been traditionally a developer and user of risk assessment methodology to ensure product safety. There is currently no interface between LCA and Risk Assessment and results might sometimes lead to confusing or conflicting conclusions.

The publication of (yearly) sustainability reports by chemical companies is very common in the sector. Life Cycle indicators and metrics are mostly used to report about the environmental performance, whereas Life Cycle Costing (LCC) or Social Life Cycle Assessment (SLCA) reports are rarely found. Instead, those reports typically include data about finance and social (number of employee, diversity etc.) The focus is at the company level and not at the product level. Those reports are still lacking conformity, which hampers a comparison of different companies or (sub) sectors.

- Traditionally, the focus in LCA in the chemistry sector is mostly based on a relative comparison of functionality between processes or product alternatives, as opposed to studies that aim at deriving absolute estimations of resource use or environmental impacts. The relative/benchmarking approach circumvents much of the issues with the model and data uncertainties usually observed in the context of LCA. As explained below, uncertainty assessments on results of LCA studies are important topics in this sector.

It is undeniable that Life Cycle Thinking (LCT) is on the rise in sector A as this approach is being increasingly understood and demanded by the management of sector A companies. While LCT approaches were pioneered predominantly by the larger companies, there is also a clear trend towards adoption by small and medium size companies (SMEs).

While LCA and related environmental tools are commonly used also for company internal purposes such as innovation driver, SLCA and LCC by contrast are not at all common in chemistry and FMCG sector today, although approaches are proposed to include also these in the value chain and process development cycle. Other approaches and company policies at corporate level take precedence. Only in some cases, single societal side effects have been highlighted at the product level.

Last but not least, collaboration along the value chain in the chemical and FMCG sector does occur (e.g. ERASM SLE project (Schowanek 2015)), but so far mostly on a need basis rather than in a systematic way. Unlike the exchange of chemical data amongst companies as, e.g., orchestrated by the EU REACH and CLP regulations (EU 2006, EU 2008), there is no legal obligation to generate and/or share life cycle inventory (LCI) information. Hence, the process remains voluntary. Consequently, data generation and exchange usually requires time-consuming preparations and/or negotiations. This is partly caused by the often competitive/confidential nature of the information that may hint at process routes and cost structure. Useful initiatives in terms of sectorial data collection and dissemination are for example the publication of ‘eco-profiles’ (e.g. http://www.plasticseurope.org/plastics-sustainability-14017/eco-profiles.aspx) or ‘Environmental Fact Sheets’ (e.g. ERASM www.erasm.org) for the specific sector.

2.2 Important regulatory issues

The application of LCT and Life Cycle tools in the Chemicals and FMCG sector, for internal or external use, is voluntary.

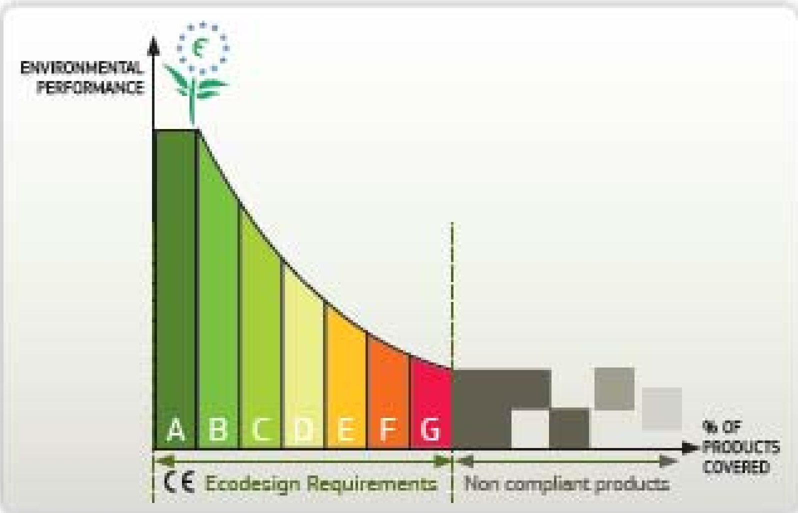

Figure 1: Eco-design vision for products from the EU Commission for products (EU Ecodesign Directive).

The eco-design vision from the EU Commission for products on the market is illustrated in Figure 1. Regulation attempts to eliminate ‘non-compliant’ products with low environmental performance (e.g. non-biodegradable surfactants or phosphates in detergents) from the market. For the products allowed on the marked, a series of sustainability performance classes could be created. Those classes would be communicated to the consumers (cf. energy label on white goods). The environmentally best performing products can also apply for an EU ecolabel. For the latter a whole guidance framework exists that is increasingly based on LCT, but the application for the label is made on a voluntary basis. Today, this is a general thinking framework, only. The exact execution and the subdivision from A to G (as depicted in Figure 1) may change depending on the class of products. However, the execution of this vision is being further researched e.g. in the Product Environmental Footprint (PEF) Pilot.

While this is not unique to the Chemical and FMCG sector it should be noted that Environmental claims in Business-to-Consumer (B2C) or Business-to-Business (B2B) context do not only fall under the ISO rules for “comparative assertions”, but moreover they can be subject to legal scrutiny and litigation as any product “advertisement claim”.

This is another reason why that methods should be well defined, scientifically robust, consistent, transparent and accurate (see WBCSD guidance document for overview of criteria (WBCSD 2014)). Thus, providing misleading or incomplete environmental information (“greenwashing”) is to be strictly avoided.

An important regulatory issue for the sector is also the regulation on registration, evaluation, authorization and restriction of chemicals (REACH) (EU 2006) as part of the strategic approach for an international chemical management (SAICM) until 2020. It entered into force in 2007 and is in operation since 2008. The main objective is the regulation of chemicals placed on the market by manufacturers, importers and downstream user’s and to protect humans and environment from hazardous effects of chemicals. The European Chemical Agency (ECHA) has been installed to examine and accept chemical registration dossiers, which have to be stepwise submitted by industry until 2018 (VCI 2016). In general, the dossiers require substance identification, the explanation of the manufacturing steps and substance use, the classification regarding hazards and the description of safety measures depending on the substance volume produced. Further, the ECHA provides different guidelines to improve practicability acquired in different REACH implementation projects (RIP) (EC 2016). Progress has been also made for the coverage of engineered manufactured nanomaterials by REACH (Aitken, Bassan et al. 2011, EC and JRC-IHCP 2011, Hankin, Peters et al. 2011, EC 2012). Harmonised classification and labelling is addressed by the European regulation in classification, labelling and packaging of Substances and Mixtures (CLP) (EU 2008). CLP requests the characterization and classification of chemical substances regarding physical, health and environmental hazards. In addition to the CLP regulation, the regulation (EG) No. 440/2008, updated in 2012 (EC 2012), determines the admitted test methods (EU 2008). As a result of the establishment of REACH and corresponding regulations, a strong motivation can be observed in the sector to couple data gathered in the framework of REACH with the assessment of toxicity in LCA. REACH has also adopted elements of LCT, as safety has to be shown at different stages of the life cycle value chain.

2.3 Existing agreements and rules in the sector

Several sustainability related actions are in place among the industrial leaders in the sector. The “Responsible Care” initiative is a good example. It is a global chemical industries initiative to improve health, environmental performance, enhance security and communication with stakeholders about products and processes. CEFIC (www.cefic.org), the European Chemical Industry Council, and its member federations adopted the European Responsible Care Security Code. CEFIC develops and runs its national Responsible Care programme with its member companies, and oversees the implementation by those companies. Current focus is on increasing the involvement of SMEs and extending Responsible Care throughout the value chain.

Regarding specific LCA studies, in principle, only the ISO Standards 14040/44 and in some business categories Environmental Product Declarations (EPD) have gained high acceptance. In fact, the lack of specificity in a broad standard such as ISO, has led to a proliferation of different approaches aimed to provide more detailed instructions how to calculate and communicate the results of life cycle studies or specific indicators such as the Carbon Footprint (GWP) or the Water Footprint for (consumer) products in the chemical sector. Not surprisingly, this has led over the last years towards a strong push back for more international harmonisation, led by concerned regulators (e.g. by EU COM, French government) as well as by multi stakeholder platforms such as The Sustainability Consortium (TSC).

However, there remain a lot of existing agreements and best practices relevant for the sector.

2.3.1 Scope and extent of LCA studies

It is widely recognized by practitioners in the sector that a full ISO 14040/44 conform LCA (with peer review) is not the best solution in all situations. Simplified or partial approaches may be followed by sector A companies depending, e.g., on the place in the Research and Development (R&D) process, the specific customer or audience, the available resources, the pre-existing knowledge about the process, the intended use of the data, etc. However, it is agreed that following a LCT approach during product development and finding a balance between system complexity and data availability is most helpful to guide sustainable innovations. Thus, different tools or subsets of ISO conform LCA have been developed (PlasticsEurope 2006).

There are also important distinctions in data needs and approaches according to the goals of the assessment, e.g. between hotspot analysis for eco-design purposes, or internal benchmarking (comparison of alternative options) or external benchmarking for communication (e.g. Product Environmental Footprint (PEF) or marketing activities. Especially external benchmarking based on LCA is currently subject to further research and debate (e.g. EU PEF pilot). The outcome of the PEF pilot will show, whether a sector can agree on common rules for sustainability assessment for a specific product category, and how much effort this takes. One of the key factors will be to define how certain/uncertain the results are, in view of public product comparisons and the definition of performance classes.

2.3.2 Pillars of sustainability addressed

The LCA methodology to determine the environmental impacts related to a product or process is well established in the sector. The sector specific WBCSD guidelines (for more information see subchapter 2.4) for accounting & reporting corporate greenhouse gas emissions (WBCSD 2001), calculation of avoided emissions (WBCSD 2013) as well as Life Cycle Metrics (WBCSD 2014), published in 2013 and 2014 support the understanding and a gradual harmonisation process. However, economic assessments such as LCC or SLCA are not mentioned in the WBCSD guideline documents, yet. As discussed before, they are today rarely used and not well accepted in the sector, although single experiences for sure have been made. Examples include the LCC studies performed regularly as part of eco-efficiency analysis by BASF or test runs with indicators such as the 'Sustainable Value Added' (Figge and Hahn 2002) as an economic indicator. Studies including all three pillars of sustainability in a comprehensive manner, e.g. applying the BASF SEEbalance® method are still rare. The sector-related WBCSD guideline towards SLCA (expected to be published mid of 2016) may pave the way for a broader acceptance and application as explorative tool to search for social hotspots in the value chain.

2.3.3 Acceptance of Life Cycle Impact Assessment (LCIA) indicators and aggregation of results

Up to now, the use of endpoint (damage) indicators is uncommon in the chemistry and FMCG sectors. Obtaining single scores by aggregation or weighting of LCIA indicators is mostly avoided in the sector as they might be based on value based assumptions, which may change over time or differ by region what would hinder a robust decision-making and reduce the transparency and understanding of the study. Midpoint indicators are also preferred due to lower uncertainty.

Thus, companies usually start the internal evaluation from a multi-indicator system, but finally focus only on the most relevant indicators for decision-making and communication. Within each endpoint, when used, the midpoints with highest contribution to the endpoint are seen most relevant.

2.4 Existing guidelines for the sector

The WBCSD, created in 1995, is an organization led by CEOs of major companies that provides a platform to work on a variety of issues related to sustainable development. In 2011, within the WBCSD, chemical sector companies launched the project “Reaching Full Potential” in order to develop harmonised approaches to corporate greenhouse gas accounting and reporting and scale sustainability efforts.

Within this project, several work streams were developed:

- Guidance on avoided product-level Greenhouse Gas (GHG) emissions
- Life Cycle Metrics (environmental and social)
- Collaboration in the Value Chain

The guidance on accounting the avoided emissions (WBCSD 2013) along the value chain enables comparing two solutions with the same user benefits, focusing on the greenhouse gases emissions. The study presents recommendations and rules to select the solution to compare (baseline solution). It has become a reference for the chemistry sector for communicating environmental product benefits. Highlights of this guideline are the procedure for selecting the baseline and the attribution of the avoided emissions among value chain partners.

The two major criteria for selecting the baseline solution are the following:

- The chemical product studied and the baseline shall deliver the same function to the user
- The baseline shall be an established alternative with a high market share (20% and above)

The guidance also proposes a qualitative approach to attribute the benefits of avoided emissions among value chain partners. The contribution of a partner to the benefits obtained from the production of a specific product is qualified as fundamental, extensive, substantial, minor or too small to communicate.

The guideline on Life Cycle Metrics (WBCSD 2014) offers a harmonised LCIA approach for the chemical sector and consequently increase the comparability of chemical products in terms of environmental performance. The guideline sets rules to define the system boundaries, to choose the functional unit and the allocation approach correctly and provides a set of impact categories to be considered in the analysis. All three guidelines have the potential to become a reference for the chemical sector and beyond, too. Some words of caution are provided regarding the use of specific indicators and assessment methods (e.g. assessment of ecotoxicity with USEtox). Those documents are built on internationally accepted guidelines such as ISO 14040/44. Indicators recommended in the guideline shall nevertheless be completed by recent developments (e.g., concerning Land Use, water footprint).

2.5 Specific LCI datasets available for this sector

2.5.1 Eco-profiles published by PlasticsEurope

PlasticsEurope (PlasticsEurope 2011) is the association of European plastics manufacturer and was the first industry organization publishing detailed environmental data. 70 eco-profile reports have now been published, in accordance with the ISO 14040 requirements. PlasticsEurope provided eco-profiles as averages (vertical averaging) to meet the external demand for information while respecting the companies need for confidentiality. It allows the aggregation of different processes with common product intermediates in case of different production sites and different production routes for the same final product.
Eco-profiles represent a standard benchmark, which allows companies making internal company benchmarking, comparing their own data against the European average and identifying possible process improvements. Eco-profiles are available in several formats such as Excel, European reference Life Cycle Database (ELCD) and EcoSpold with documentation. Eco-profiles refer to a quantity of 1kg of a given polymer (cradle-to-gate) and do not consider its functionality. As polymers are not functionally equivalent, the comparison of several polymers is not possible.

Product Category Rules (PlasticsEurope 2006) have been established as well for the product category of uncompounded polymer resin including reactive polymer precursor, in accordance with the ISO EN 14025.

2.5.2 SLE ERASM Surfactants

14 major companies collaborating within ERASM have compiled Cradle-to-gate life cycle inventories (LCIs) for the production of a series of common surfactants used in European detergents and personal care products (www.erasm.org). The objective of the SLE project was to update or establish the environmental profile of the major commercial surfactants and their precursors, taking into consideration actual surfactant production technology and aiming for consistent and high quality (background) data. The new data is intended to support the increasing use of LCA in industry as well as in various policy initiatives.

The industry initiated SLE project has delivered new and updated LCI datasets for 15 surfactants and 17 precursors in three common LCI exchange formats: ILCD, Eco-Spold v.2 and GaBi. Several preconditions had to be met and various complexities solved to enable an industry initiative of this scale, e.g. the existence of a strong and active sectorial organisation, budgets (10 - 40 KEuro/inventory), internal know-how and passion to start the project, access to independent expertise, legal support to set up various confidentiality agreements amongst the partners, use of the "trio concept" with vertical averaging to guarantee that the published data remain anonymous, etc. (Schowanek 2015).

2.6 Consistency of LCA studies in the sector

There is overall a good scientific consistency in some of the LCA studies in the sector A, such as those studies published on detergents/cleaners by different companies or other LCA practitioners. This is the result of continued work over more than a decade. Recently, the detergent industry has contributed and reinforced this process by publishing a joint LCA for 6 categories of cleaning products (Golsteijn, Menkveld et al. 2015). There is consistency in the key messages from the detergents/cleaner sector, e.g., the importance of the use phase of detergents, benefits of compaction, the need to consider ecotoxicity and water use.

However, this is not a general rule: many other product categories are unexplored and/or there have been major differences in assumptions (e.g. related to functional units, goal & scope) between the practitioners, which results in a lack of consistency concerning some specific topics or products. Thus, the PEF pilots can be seen as an important attempt to explore the possibility for harmonisation within and across product categories.

LCA studies of the chemistry sector also present a good consistency concerning goal and scope, impact assessment methods used and reported indicators. Major differences are observed in the allocation approach used, results communication and in the assessment of bio-based products. As explained in the section 3.4.4, different methods are used to calculate the emissions from Land Use Change and to handle biogenic carbon so that studies published concerning the assessment of renewable materials often lack good comparability.

2.7 Cooperation in the sector on LCA data management/ exchange

LCA data management in companies, within the sector or over supply chains is often rate- and quality limiting. It can be complex especially across the supply chain because of confidentiality issues (directly related to the accessibility of disaggregated data). It can be expensive, too, up to several 10 KEuro per state-of-the art and validated dataset. It has to be mentioned that collaboration between (competing) companies – even if it is on environmental or sustainability topics of general interest - falls under the EU competition legislation and this has a significant impact on project management. In some cases, a topic can be considered of general importance and non-competitive or pre-competitive, which may facilitate data exchange amongst industry. Nevertheless, seeking legal guidance and the use of intermediary consultants covered by confidentiality agreements is often needed. These procedures may slow down and form practical barriers for routine collection and exchange of environmental data. Thus, sector organizations can play a vital role to facilitate and organize data collections. When the exchange of primary LCA data occurs, this is mostly in the form of aggregated datasets (black box).

When direct sharing (at B2B level) of primary data for a specific product is not possible, an industry wide initiative can be a solution to overcome the issues of confidentiality. Datasets or Life Cycle Inventories are published based on a vertical or horizontal averaging (e.g. the ERASM SLE project see also subchapter 2.5).

Finally, LCA data from databases, which represent either a technology mix or a specific technology are often a good solution and can be sufficient depending on the goal and scope of the assessment. Supplier specific primary data are not always required.

Nevertheless, the use of inventory data is still rated critical (Saygin, Worrell et al. 2012), despite much progress made on databases in the last decade. On the other side, companies in the sector see also problems to submit data to inventory databases such as ecoinvent (Frischknecht, Jungbluth et al. 2005) due to confidentiality reasons related to the disclosure of unit process data.

LCA practitioners face difficulties because important discrepancies can be observed from database to database or from generic to supplier specific data. An interpretation of these discrepancies is only possible if an accurate and complete data documentation is provided by the supplier. Expert knowledge is always needed for interpretation. To tackle this issue, a dataset documentation has been recommended by the MEASURE project team intended to address data suppliers (see **background document** “Challenges of cross-sectorial sustainability assessment“.

Nonetheless, due to changing methods and evolving databases, companies may face difficulties to do long term R&D direction settings based on LCA (e.g. lack of solid eco-toxicity indicators to guide product composition based on LCA). For the future, focus will have to be put on exchange of knowledge and experience, transparency about modelling rules etc., but also on regional databases and.

3 Critical topics specifically important for sector A

Besides the common ground described above, there are a lot sector specific topics, which are partly still under critical discussion.

3.1 Importance of the assessment of the environmental impact of energy

The European chemical industry has a significant role to play in saving fossil fuels and mitigating climate change, since it is on the one hand a major energy user but on the other hand a highly important enabler of energy - and emissions- saving solutions in all sectors of society.

Energy required for production represents indeed an important contribution to the environmental impact of chemicals and consumer goods. According to a recent report from the U.S. Energy Information Administration, e.g. the share of heat and power supply on the generation of greenhouse gases emissions resulting from the production of bulk chemicals in the U.S. is more than 40 % (EIA 2015). Consequently, energy is also a major category while reporting Corporate GHG emissions not only in the U.S. but also in Europe (Scope 2 emissions). It should be mentioned in this context that an analysis of Saygin and colleagues (Saygin, Worrell et al. 2012) revealed indications for errors and inconsistencies in national statistics, e.g., in the German Energy Balances as well as in the IEA Energy Statistics for the chemical industries reported energy use. They pointed out that unless these are minimized by revisions, it is not possible to derive robust conclusions on the actual development of energy efficiency in the chemical industry based on those statistics. This finding implies that it is also not possible to monitor energy efficiency improvements of the sector based on robust data. The latter is pivotal in view of the European Commission's goal to improve energy efficiency or to answer questions whether national energy policies were effective.

For these reasons, calculation rules have to be agreed within the sector for the assessment of energy generation. Energy to produce chemicals is either generated at site or purchased. One key question the sector has to agree on is the allocation of steam and power in Combined Heat and Power (CHP) plants. There is a variety of methods for allocating emissions from CHP plants: work potential and the efficiency methods are the most common. The efficiency method is an allocation based on the fuel required to produce power and heat streams, using the assumed efficiency. The work potential method is based instead on the useful energy and on the ability of the heat to perform work. Today, most standards recommends the use of the efficiency method (WBCSD guideline 2013 (WBCSD 2013), GHG Protocol, ISO 14010 standards, Product Category Rules). Thus, the advice on using harmonised allocation rules for CHP plants published in the WBCSD guideline 2013 (WBCSD 2013) are an important step towards a better consistency of LCA data and reported GHG emissions within the sector and a better transparency and communication along the value chain (Figure 2).

Product Category Rules also provide a set of efficiency factors for several technologies. When energy is generated at the plant site, company owns the data and has the possibility to develop specific datasets for energy according to this guideline. When the energy is purchased instead, a dataset of the country specific grid mix is typically used when supplier specific data is not available.

Preferred CHP emissions allocation method					
Fuel type	Technology	Alternative heat efficiency (%)	Alternative electricity efficiency (%)	Illustrative CO_2 emission allocation	
Biofuel	Steam cycle, heat and power	90%	38%	29%	71%
	Steam cycle, heat and power, flue gas condensation	110%	38%	25%	75%
Waste	Steam cycle, heat and power	90%	35%	27%	73%
	Steam cycle, heat and power, flue gas condensation	100%	35%	25%	75%
Black coal	Steam cycle, heat and power	90%	46%	33%	67%
Natural gas	Steam cycle, heat and power	90%	47%	33%	67%
	Steam cycle, heat and power, flue gas condensation	105%	47%		70%
	Combined cycle, heat and power	90%	58%	38%	62%
Oil	Steam cycle, heat and power	90%	46%	33%	67%
Oil shale	Steam cycle, heat and power	86%	38.9%	30%	70%

Emissions allocated for a CHP with electricity to heat ratio of 1 : 0.96

Figure 2: Efficiency factors for several technologies (PlasticsEurope 2006).

3.2 Assessment of toxicity in LCA

Toxicity, risk assessment and safe use of its products and production processes are important matters in sector A (WBCSD 2014). This is also an important regulatory issue. Nevertheless, the handling of toxicity in LCA is both a key topic of discussion and a bottleneck.

Several indicators have been used in the last decade to assess toxicity in LCA (such as the Human Toxicity Potential from the CML method, the Human Health endpoint category from RECIPE) which are based on different background data and describe different aspects of toxicity.

To harmonise and improve the assessment of toxicity in LCA in general, the USEtox model (Hauschild, Huijbregts et al. 2008, Rosenbaum, Bachmann et al. 2008) was developed within the UNEP SETAC Life Cycle Initiative, by experts at the origin of several models and impact assessment methods (CalTOX, IMPACT 2002+, USES-LCA, EDIP). This initiative culminated in the published USEtox-model in 2007 (Rosenbaum, Margni et al. 2007). The estimation of fate, exposure, effect and damage factors and the background of the model are comprehensibly defined in the literature (Murray and Lopez 1997, Bennett, McKone et al. 1998, Crettaz, Pennington et al. 2002, Pennington, Crettaz et al. 2002, Huijbregts, Rombouts et al. 2005). This transparency is also implemented in the provided excel-tool for USEtox and allows comprehensibility in the selection of characterization factors for single substances. The characterization factor´s uncertainty was reduced during the progress in harmonisation and is now lower than in previous toxicity models, but still higher than in other impact categories (Hauschild, Huijbregts et al. 2008, Rosenbaum, Bachmann et al. 2008). The first version of the model (USEtox 1.0) included human toxicological characterization factors for more than 1200 substances, which surpasses the substance coverage of the other models, e.g. USES-LCA 2.0 in ReCiPe with around 1000 and IMPACT 2002+ with around 800 substances (Hauschild and Huijbregts 2015). Beside the advantages, improvements were still required, e.g. in the assessment of metals, pesticides and amphiphilic substances to make the assessment method easier to implement (Hauschild, Goedkoop et al. 2012). Further development and improvement have also been realized in the previous years (in the method, in the documentation, characterization factors for pesticides (Fantke and Jolliet 2015) and metals), resulting in the recently published version USEtox 2.0 (Fantke 2015).

The USEtox-model is today the recommended model for human toxicity at midpoint level by ILCD (EC and JRC-IES 2010) and is tested on the pilots of the PEF project. It represents the most updated model for assessing toxicity.

On the other side, the USEtox model is still criticized for several reasons:

- Lack of transparency and pragmatism. The lack of documentation of the background calculation approach (use of weighting factors for example) and the lack of transparency concerning the importance of the several input data required make the overall results very challenging to interpret (especially for LCA practitioners who are not toxicological experts). This issue might be overcome with the recent improvement of the documentation.
- The ‘safe is safe’ paradigm of risk assessment is difficult to combine with the ‘less is better’ paradigm of LCA.
- The units of (eco)toxicity and the model are complex and cannot be easily used for communication to non-experts.
- Low data availability: there is currently no strong link between data required for REACH and the one required for USEtox. Moreover, both analysis (based on REACH data and USEtox) might lead to different results. Consequently, still many experts in toxicology in industries are not aware of this method and have other expectations.
- Results present a high uncertainty and sensitivity what lead to communication issues. As a result, EPDs for example do not contain USEtox based toxicological impacts at all, although there is common agreement that those data are im-

portant in the building sector.

For these reasons, other initiatives are currently under development to create a tool more adapted to business needs, pragmatic and REACH based (e.g ProScale). The ProScale method might be very promising for sector A, but is currently at its early development so that it can neither be recommended nor judged at the present time.

Nevertheless, an LCA for a chemical product without ecotoxicity assessment is considered incomplete. (cf. USEtox WS EU – January 2015, hosted by EC). For these reasons, the USEtox impact assessment method is indeed used in LCA studies in the sector, but presently plays only a minor role in the decision-making process.

3.3 Water Footprint

Methodological developments in the context of water footprinting have gained a lot of momentum over the last 2 - 3 years especially within FMCG industries. Various methods have been developed to assess water usage at different scales. However, due to their recent development, hardly any experience gained from their application in broader case studies is available yet.

The Water Footprint (WF) is calculated as the total amount of green water (rainfall), blue water (fresh water stored in lakes, rivers, and aquifers) and gray water (water needed to dilute aquatic pollutants). Those three impact pathways are proposed, including the availability of freshwater for contemporary human activities, existing ecosystems, and future generations. These pathways are also linked to endpoint indicators such as human health, biodiversity, biotic productivity, and abiotic resources (Pawelzik, Carusb et al. 2013).

Although freshwater consumption is the key driver for many methods under development, the use of freshwater throughout a product‘s life cycle is often neglected in current studies. One remaining problem for a broader assessment is that today’s LCA databases only classify the input and output fluxes according to the watercourses from which the water is withdrawn and to which it is released. In addition, the information content of those databases does not include up to now geographical nor quality-related information. Moreover, the correctness of the available data is arguable as it is unclear whether all relevant water flows, especially those from the background system and cooling water run in circulation systems, are included or not. These doubts regarding the correctness of data are increased because there are large differences (up to a factor of 10) between the water use and consumption data of materials determined from different databases. Overall, there is a high uncertainty on the results due to poor water inventory databases (missing for regionalized data).

Evaluating WF from products with freshwater consumption also often shows a dominant influence by the product use stage dependent on direct (foreground) and indirect (electricity) water consumption. As a result, FMCG and the Chemical industry even more have to handle the problem that a single product may have a very different footprint, depending on how it is used. This makes the methods developed so far unsuitable for communication.

Thus, not only further improvement of the methodologies to assess water use, but also further efforts to improve the data availability and quality are required, before water footprinting can become an established LCIA method. Consequently, it is not known yet, whether the indicators found will be practical and relevant for production sites and product use (e.g. for hotspot analysis to identify product improvement options).

3.4 Assessment of renewable materials

The production of bio-based materials (e.g. biopolymers) has been growing in the last decades. According to Weiss et al. (Weiss, Haufe et al. 2012), biomass represented already 10% of the feedstock of the European chemical industry in 2008. Thus, there is currently a high interest for LCA studies comparing renewable versus petrochemical feedstock in sector A. In this context, specific topics such as the assessment of land use (land use change, land occupation, land transformation) are relevant. The best practice for the assessment of the sustainability of bio-resources also requires an assessment of the social impact of sourcing of bio-based feedstock. The production of vegetable oil (for example palm oil in Malaysia) has many positive consequences on the economic development of the country so that social and economic issues should be considered. On the other side, the debate “fuel” versus “food” also plays a role in this sector, but cannot be currently assessed in sustainability assessment.

Furthermore, the assessment of second (and possibly third) generation of biomaterials may become soon an important topic in LCA studies of the sector.

3.4.1 Land Use Change

Quantifying the emissions from direct Land Use Change (dLUC) is a very challenging issue that LCA experts from the sector are dealing with when assessing the sustainability of bio-based products.

While the ISO 14040 and ISO14044 standards do not provide any recommendation on how to assess the effect from LUC, the GHG protocol 2011, states that emissions from LUC have to be reported separately considering the carbon stock change which occurred during the last 20 years or within a single harvest period. Indirect LUC (iLUC) does not have to be reported, as there is currently no agreed methodology. According to IPCC, they are several carbon pools for calculating the carbon stocks: aboveground biomass, belowground biomass, soil organic matter, and cultivation on peatland.

A first task for calculating the emissions from LUC consists in determining the shares of land prior land use (forestland, grassland, cropland, etc.) and then the carbon stock of these lands prior and after use. The specific site where a land unit is used is generally not known but the country of origin is known. Information costs would rise considerably if the exact location of every land use in a product's life cycle would have to be registered. Moreover supply chain of bio-based products might be very complex (e.g. palm derivate). Therefore, average values at the country or at the regional level are often used for estimating the carbon stock or shares of land. Nevertheless, this data might differ from publication to publication and methods for estimating them are not widely agreed (weighting or averaging approaches). In addition, there is currently no consensus about data source, calculation method and categories of carbon pools to be considered (especially concerning soil organic matter and the cultivation on peatland).

Results present a very high sensitivity to the calculation approach chosen to calculate the emissions from LUC, data sources for carbon stock or categories chosen and cannot be easily interpreted or even communicated. Moreover, taking a decision might not be possible due to the wide range of results obtained when using different data and assumptions, as illustrated in Figure 3 which represents the GWP of a vegetable oil found several databases and publications:

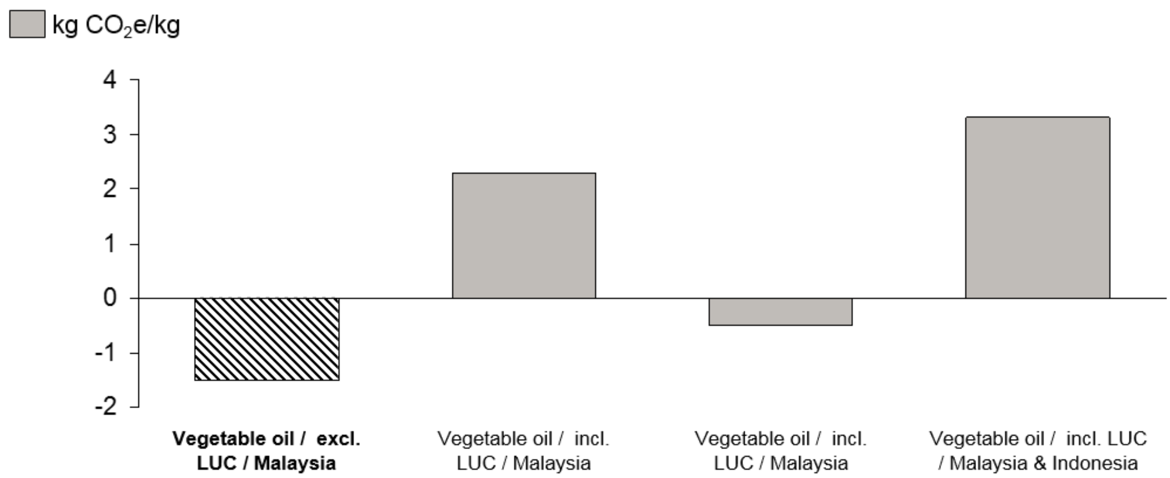

Figure 3: GWP of a vegetable oil from several databases and publications. The highest GWP of the vegetable oil includes the emissions from cultivation of peat land while the lowest GWP was calculated based on the data from the PAS 2050-1:2012 (BSI 2012) and the ENVIFOOD Protocol (Food-SCP-Roundtable 2013). Other data were found in literature or in LCA databases.

However, the use of generic data might be possible within the sector or for a product group if an agreement is made between different companies to use the same dataset. For instance, within the ERASM Surfactant Life Cycle and Ecofootprinting project, LCA datasets have been built for several bio-based surfactants. In the framework of this project, an agreement was made on the calculation rules to account for the emissions for Land Use Change so that the same data will be used within the sector. Even if the absolute results do not exactly represent the reality, the results will remain comparative for all products of this sector.

Concerning the impact of iLUC, there is no agreement about the calculation approach, so iLUC is excluded in most of the LCA published (such as the SLE Surfactant study). Nevertheless, tools have been recently made available, such as the one developed alongside the PAS 2050-1 standard and built based on the GHG protocol (PAS 2050:1 land use change assessment tool). It provides a predefined way to estimate GHG emissions from land use change when the previous land is not known. It is based on several scenarios for previous land use and on data from FAOSTAT. PAS 2050-1 is currently referred to in the PEF standards. This tool might offer a harmonisation for estimating emissions from land use change and a better comparability of the published studies.

3.4.2 Assessment of land occupation and land transformation

Another unsolved problem is that land use and changes in land use can lead to other unintended environmental impacts, such as carbon loss from soils, soil erosion, nutrient depletion, water consumption, and loss of biodiversity. Thus, the impacts associated with land occupation must be considered in all compartments and land occupation or transformation shall also be assessed based on qualitative changes, not only on the resulting CO_2 emissions. Depending on the initial/final quality of the type of land used, many environmental factors such as climate but also restoration times may vary considerably. Some ecosystem types might never be restored again either. However, the main limitation of models estimating these factors is that large uncertainties exist. They are primarily related to the underlying data (e.g. yields on newly converted land, rate of agricultural intensification, price-yield elasticity, data concerning biodiversity loss) as well as to projections on the location and type of land use changes, resulting production and trade patterns of biomass, price effects and related price elasticity, and to the accounting for co-products (Pawelzik, Carusb et al. 2013). Non-convergence of the methodology for the assessment of land use in LCA still persists because most of the proposed methodologies deal so far with different aspects of land use impacts and are therefore conflicting. Some LCIA indicators for the assessment of land use impacts are also poorly connected to actual impact (e.g. land occupation / transformation).

LCIA categories such as water use, soil degradation and impacts on biodiversity are often excluded from the LCIA of bio-based materials due to persisting methodological problems and limited data availability.

As an example, soil degradation comprises any undesirable change in soil characteristics including the loss of soil productivity caused by wind and water erosion, chemical degradation (loss of nutrients, salinization, acidification, or contamination), and physical degradation. All types of soil degradation decrease the productivity of land, resulting in higher requirements of, e.g., fertilizer inputs, which in turn can enhance acidification and aquatic eutrophication. However, a broadly accepted methodology for assessing soil erosion in the LCA studies of bio-based materials is still not found.

Consequently, land use impacts are not being widely integrated into LCAs of sector A. Instead, the actual impact is often managed through other environmental management systems (certification schemes such as e.g. the Round Table on Sustainable Palm oil (RSPO), or the Forest Stewardship Council (FSC) to manage habitat loss and deforestation) showing the limits of LCA.

3.4.3 Biodiversity

Similar issues can be encountered when assessing the impact of a product on biodiversity as a consequence of land use changes or other local/regional stressors such as ecotoxicity, acidification, eutrophication as well as global stressors such as climate change (Pawelzik, Carusb et al. 2013). The inclusion of loss of biodiversity in LCA is still adjudged to be problematic, because it does not have a clear flow character in and out of the product or process system and it often has a local focus. Detailed biodiversity data on the distribution of species across many taxa are incomplete on a global scale (Pawelzik, Carusb et al. 2013) and taxonomic and geographic coverage remain problematic due to the complexity of the impacts and dependencies between several environmental effects.

3.4.4 Biogenic carbon

An additional point of open discussion is the accounting of stored carbon. Biogenic carbon contained in bio-based materials shall be deducted when calculating the total carbon emissions (fossil + biogenic). The draft ISO standard to assess the carbon footprint of products states that when calculating the carbon footprint of a product's entire life cycle, all the carbon emissions and removals from the atmosphere (biogenic and fossil) must be taken into account by applying a timeframe of 100 years. In line with draft ISO standard (DIN CEN ISO/TS 14067), all carbon emissions and removals (fossil and biogenic) that occur within the 100 years period are quantified and treated as if they occurred at the beginning of the time period.

There are several sources and emissions of biogenic carbon during the life cycle of a bio-based product (Figure 4):

- Carbon uptake during crops' growth (converted in CO_2equivalent)
- Carbon release during processing of bio-based products in form of CO_2 or methane (for instance during a fermentation process) (converted in CO_2 equivalent)
- Carbon emissions during the end of life treatment

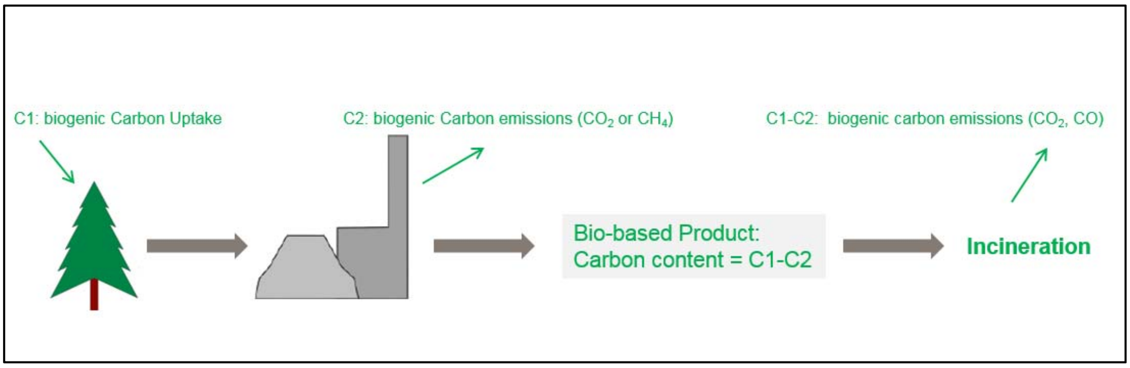

Figure 4: Biogenic carbon balance over the life cycle of a bio-based product.

The biogenic carbon balance is neutral over the full life cycle, which means that the biogenic carbon taken up during the growth of the crop is either released during the processing or embedded in the product/by-products. Carbon embedded in the products will finally be released at the end of the product's life. As these flows has an important contribution to the product's GWP, it is recommended to always check if the biogenic carbon balance is closed over the full life cycle (for a cradle-to-grave analysis) or that the biogenic carbon embedded in a product in an LCA corresponds to its actual carbon content (i.e. based on its stoichiometry or how it could be confirmed by an elementary analysis) for a cradle-to-gate analysis.

The biogenic CO_2 equivalent balance is not necessarily closed over the life cycle, because carbon can be released in the form of methane, which has a larger characterization factor than CO_2. On the other hand, allocation based on price or mass applied between products and by-products might compromise the biogenic carbon balance: after a price allocation, the carbon embedded in products (according to the LCA) does not reveal the reality (i.e. the real carbon content of products) and the balance might not be closed, resulting in a biased GWP. To overcome this issue, the MEASURE project team recommends either to conduct a segregated allocation (price/mass/energy content allocation for all flows except for the biogenic carbon, which has to be allocated based on the carbon content of products) or to correct the biogenic balance manually in the modelling.

Based on the experts' experience from the MEASURE project, this methodological issue is only recognized as a challenge by a small part of the LCA community, working with bio-based products. Many different approaches have been used in the last years, so that there are inconsistencies in LCA studies of bio-based products published in the sector. This problem should be of larger awareness as bio-based products are now used in the processing of many products and for a broad range of applications. They also represent a cross-sectorial topic (for instance, implementation of bio-based composites for automotive parts). The recommendation how to handle biogenic carbon given in this section is based on experiences in the SLE ERASM project and on recent publications (Vink and Davies 2015). The procedure represents the current "best practice".

Also the effect of carbon storage in products might reduce the impacts associated with carbon emissions (e.g. delay of radiative forcing). There is currently no agreement on how to quantify it (Pawelzik, Carusb et al. 2013). Nevertheless, the different methods proposed agree that the positive effect would only be relevant for long-living products (>100 years), which is not the case for bioplastics or most consumer goods.

Other approaches recommend excluding completely biogenic carbon from the LCA as this is neutral over the full life cycle (ADEME's LCA Methodology for bio-products). However, this cannot be recommended especially when cradle-to-gate LCAs are made and communicated over the supply chain.

3.5 Product Environmental Footprint specificities for sector A

Leading companies of the sector are currently engaged in exploring the possibilities and limitations of Product Environmental Footprints (PEF). They see the challenge of the PEF around the question whether LCA can be standardized within a sector to the extent that it becomes possible to compare and benchmark products across brands – for the sake of consumer information. The inherent uncertainty of LCA is seen as one of the main arguments against a comparison of products. Discussion is ongoing on whether it is a possible and workable framework, whether it will truly drive sustainability improvements (both, at company and customer levels) or should be abandoned in favor of simpler and more effective schemes (For general information see **background document** "Current state in LCSA").

4 Specific tools applied from R&D to full scale

Tools for assessing the sustainability of projects in innovation projects present many similarities between companies from the sectors chemistry and FMCG. All of them allow an implementation of sustainability in the product or process development process.

Based on the experience of companies involved in the MEASURE project and based on the knowledge shared during the MEASURE workshops (see **background document** "MEASURE survey results"), such iterative approaches seem to be implemented in most of the large companies from this sector. They are good examples of the use of LCT for decision-making and for assessing how sustainable are innovations. A non-exhaustive list of examples is discussed below.

BASF was one of the pioneers in implementing sustainability thinking and life cycle based comparative assessment of process or product alternatives into the company-internal decision-making (Saling, Kicherer et al. 2002). The company developed its own eco-efficiency assessment and later the SEEbalance method, which includes the environmental, economic and social dimensions of sustainability.

At Evonik Industries, LCT is used at different levels of the product development for assessing innovations in the R&D stage-gate process. For that, specific tools as well as a *pragmatic* approach were developed because a full ISO compliant study cannot be conducted at this stage (due to data availability, resources and timing related issues). For this purpose, the strategic research unit of Evonik, Evonik Creavis GmbH, developed, jointly with the Wuppertal Institute, the Idea to People, Planet and Profit (I2P^3) Process, in order to take into account the environmental and social dimensions in all projects (Figure 5).

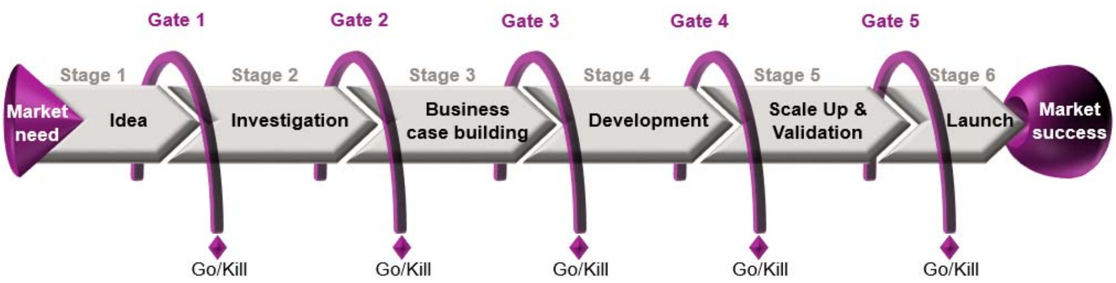

Figure 5: Idea to People, Planet and Profit (I2P^3®) Process (Kreidler 2015).

At the very first stage, the planet and people dimensions are assessed at a very generic and qualitative level (Gate 1). At Gate 2, the assessment becomes more detailed but remains qualitative. For instance, several categories are investigated such as Greenhouse gases, Waste and Energy. From Gate 3, a quantitative assessment is done. A

LCA study is conducted for the solution developed and compared to a benchmark solution, based on a cradle-to-grave analysis. The choice of the benchmark solution is made according to the guidelines of the WBCSD. A set of impact categories is chosen based on the impact categories of the CML method (such as GWP, ADP, POCP; EP etc.). Additionally, the quantity of waste generated, water consumed, land occupied and the criticality of raw materials used are investigated. Concerning the People dimension, a qualitative assessment is made. When few data is available, a qualitative assessment can be made (for instance for water used upstream) but in this case, a poor quality seal is attributed to the category.

In order to support the decision-making, clear hurdles and a scoring system have been defined for each category in order to quantify if the solution leads to a significant improvement or deterioration in comparison to the selected benchmark (Figure 6). Each project needs to perform on a minimum financial level, but a project with outstanding planet impact might be chosen over a project with superior financial impact.

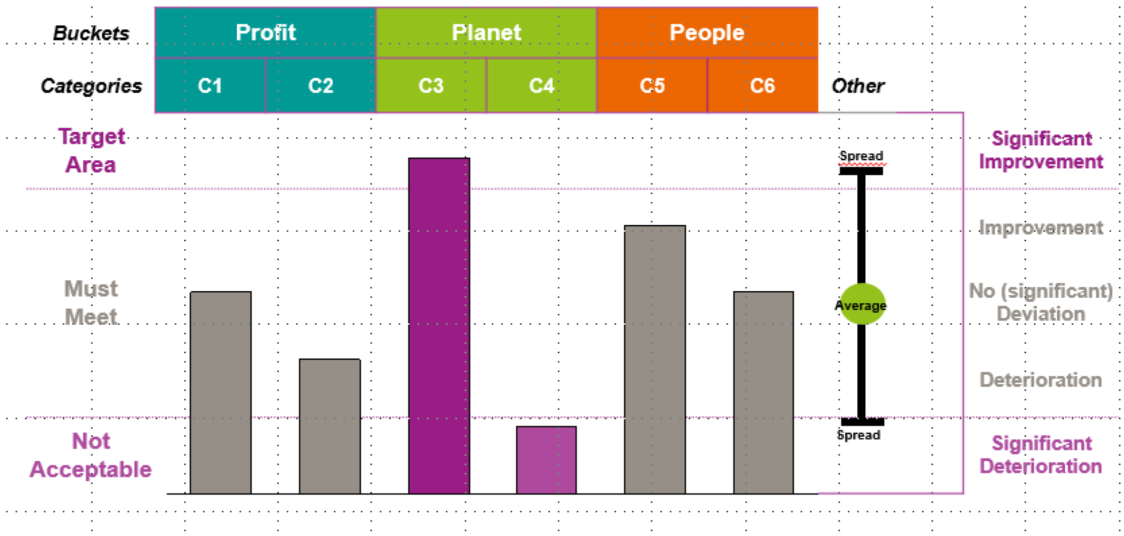

Figure 6: Project assessment for selected categories (C1 to C6) (Kreidler 2015).

In Procter & Gamble, different LCA-based tools are used along product development stage; starting from self-made category-specific LCA-based scorecards, over screening LCA, to full (ISO) LCA as more data becomes available whilst still influencing the R&D stage-gate process (Figure 7).

It is recognized at Procter & Gamble that early assessments and interventions are the most effective, and that it is important to bring the life cycle tools to the R&D bench. By being able to use and experience LCA and eco-design tools, all the departments within the company get more engaged into the matter and a bottom-up interest within the company can be created.

An important tool to guide the overall sustainability direction of the company and set priorities is the so-called “company footprint”. For a series of life cycle indicators, product categories and life cycle stages, the total company impact is calculated as the impact per unit of product multiplied by the global sales of that product. Hence, the environmental impacts take into account the market (“scale”) for that product. Therefore, even smaller improvements on products with large sales can have a positive contribution.

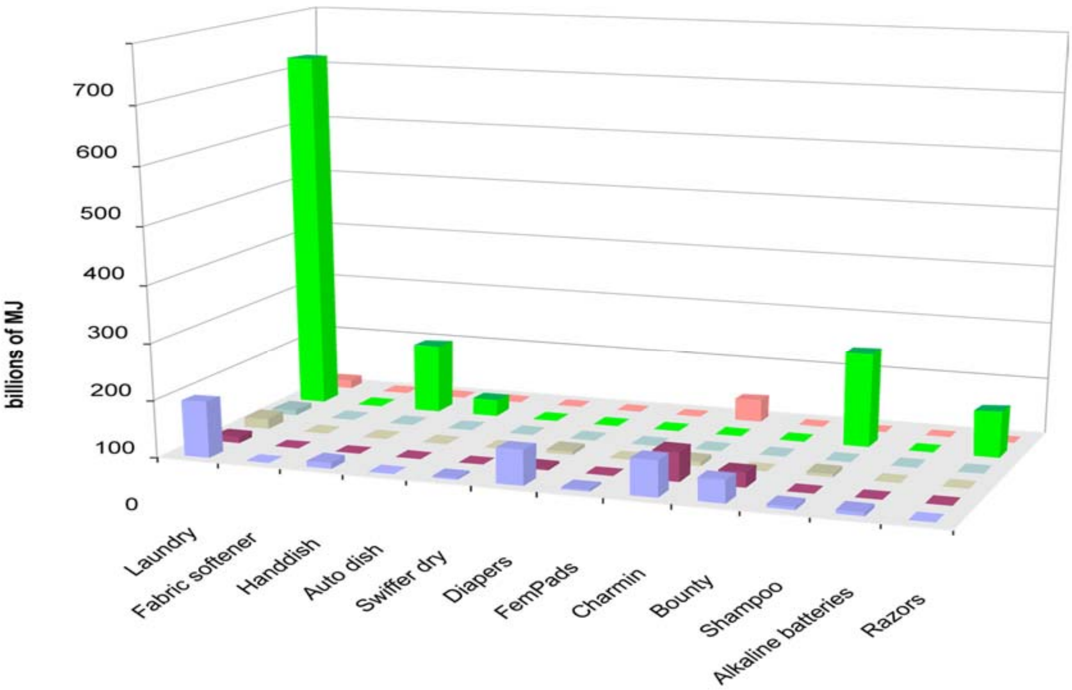

Figure 7: Example of P&G company footprint for the indicator of cumulative energy demand from 2010. The graph allows identifying hotspots, for which a company action plan can be developed for existing and new products.

Henkel developed tools to anchor sustainability in the innovation process and assesses sustainability at different stage of the development of the project (Figure 8). At the concept level, the relevant sustainability topics are identified (Performance, Health and Safety, Social Progress, Materials and Waste, Energy and Climate and Water and Wastewater) and during the development stage, a semi quantitative assessment of these topics is realized based on a scoring system (Figure 9). At the validation stage, a quantitative assessment is done based on the “Henkel Sustainability Master” which allows identifying hotspots along the value chain to know where innovations can have the greatest impact. At the Launch Control stage, a reviewed quantitative assessment is performed.

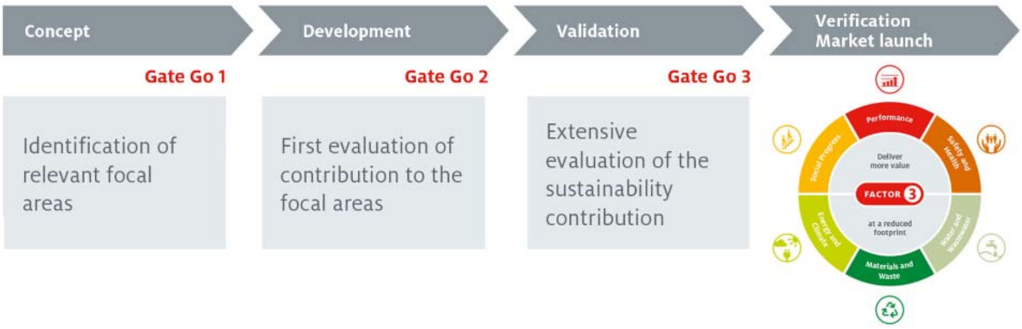

Figure 8: Sustainability evaluation in the Henkel innovation process (Henkel 2016).

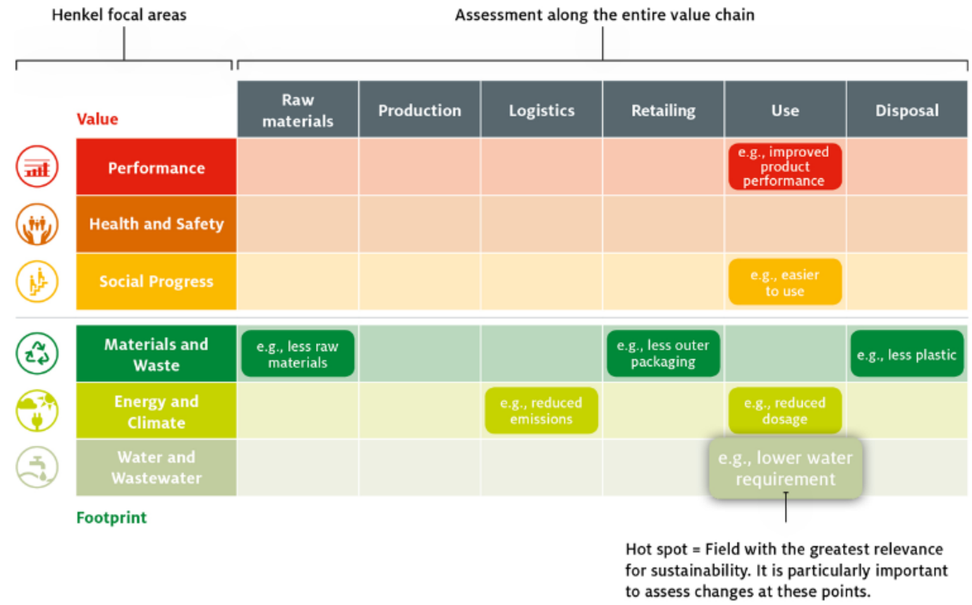

Figure 9: Henkel Sustainability Master ® (Henkel 2016).

Unilever also developed tools to implement sustainability in R&D projects: a qualitative assessment is performed at the “feasibility” and “capability” stages followed by a quantitative assessment after the “market ready gate” (Figure 10). The assessment is also performed at a comparative level between the new product and a comparison product. The expected changes are expressed in percent for several environmental metrics: GHG, waste, sustainable sourcing and water.

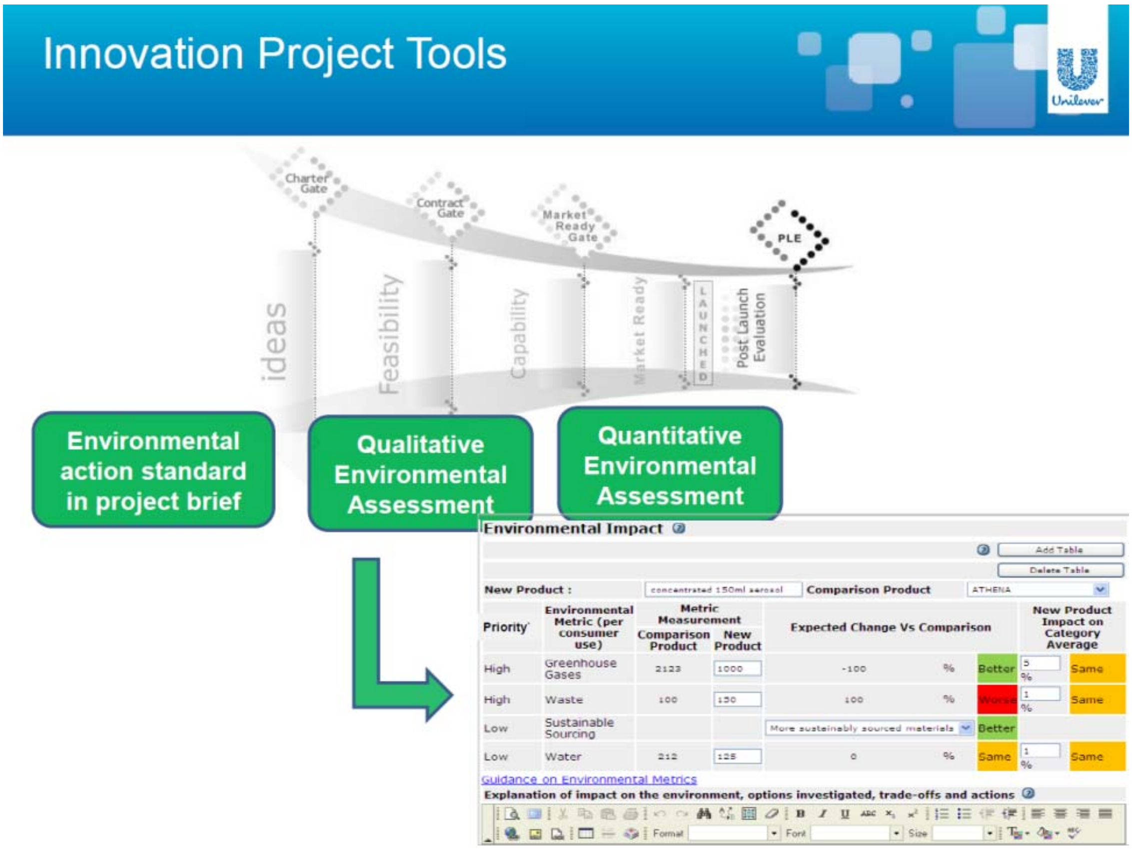

Figure 10: Tools for assessing innovation project by Unilever (P. J McKeown 2011).

5 Outlook: key areas of further development

Full implementation of LCT

Generating environmental profiles (cradle-to-gate) for material or product is a first step. However, full cradle-to-grave studies are required for decision-making and to compare products based on their performance. For this, a more intensive cooperation along the value-chain is needed.

Sector specific guidelines such as WBCSD's and agreements on specific topics should be enhanced as this is the key for a better consistency, comparability and transparency of sustainability assessments. Many calculation rules or best practices have been developed by the WBCSD and could be transferred to other sectors.

LCC and Social LCA methods are less accepted than LCA and less operational in sector A. Significant additional efforts in methodological improvements, standardisation and better adaption to corporate operational decision making are needed to gain a wider acceptance.

Calculation of LCIA results

- The use of comparative approaches is recommended in sector A for a better implementation of LCA in decision-making.
- The functionality shall be taken into account by the choice of the functional unit in environmental profiles so that users can make a fair comparison of different products. The comparison at the mass level often does not give realistic information about the sustainability performance.

Assessment of toxicity

A stronger and more consistent link between REACH data and data required for the USEtox tool is highly demanded by the Chemical industry in Europe. It would allow a better adaption of toxicity methods in LCA to business needs and a much more widespread use in decision-making as well as communication to the consumers. First of all, a better communication between the USEtox method developers and toxicological experts would help to overcome scientific issues. To report toxicity in LCA today, it is nevertheless recommended to use USEtox as this is the most developed method, although there are methodological issues which are still not solved.

Assessment of water footprint

The WF method should be tested by industries in the sector to gather experience. In parallel, further development of LCA databases with regionalized data is necessary to facilitate the implementation.

Assessment of bio-based products

Land Use Change:
Two solutions might be offered for assessing LUC of bio-based products:

- Not using generic data but collecting specific data concerning supplier, cultivation practices and plantation in order to reduce the data uncertainty. This is nevertheless related to a very high effort especially when it deals with palm derivatives, which are often bought as a mixed from several supplier.
- The use of generic data might be possible within the sector or for a product group if an agreement is made between different companies to use the same dataset.

Biogenic carbon storage:

- Check that the biogenic carbon balance (and not the carbon dioxide equivalent balance) is closed over the full life cycle (for cradle-to-grave).
- For cradle-to-gate, check that the carbon stored in the product is consistent with the chemical structure of the product.
- A special care has to be given in case of allocation, which can shift the balances and impact the GWP.

Harmonisation of evaluation approaches guiding developments from R&D to full scale

There is a common understanding in industry on how the decision-making process during the development of new processes or products can be accompanied by LCA. Thus, it is recommendable that:

- The accepted stage-gate approaches from industry in sector A, including:
  - starting with screening methods and end with full LCA
  - setting clear hurdles and a scoring system for each category considered in order to quantify if the solution developed will result in a significant improvement or deterioration in comparison to the selected benchmark

  is introduced in European collaborative projects, including SPIRE projects.

6 Abbreviations

ADP	Abiotic Depletion Potential
B2B	Business-to-Business
B2C	Business-to-Consumer
CLP	Regulation on Classification, Labelling and Packaging of Substances and Mixtures
ELCD	European reference Life Cycle Database
EP	Eutrophication Potential
EPD	Environment Product Declaration
EU	European Union
FMCG	Fast-moving consumer goods
GHG	Greenhouse Gas
GWP	Global Warming Potential
ISO	International Organization for Standardisation
LCA	Life Cycle Assessment
LCC	Life Cycle Costing
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
LCSA	Life Cycle Sustainability Assessment
LCT	Life Cycle Thinking
LUC	Land Use Change
dLUC	Direct Land Use Change
iLUC	Indirect Land Use Change
PEF	Product Environmental Footprint
R&D	Research and Development
REACH	Regulation on Registration, Evaluation, Authorization and Restriction of Chemicals
SLCA	Social Life Cycle Assessment
UNEP/SETAC	United Nations Environmental Programme/Society of Environmental Toxicology and Chemistry
WBCSD	World Business Council for Sustainable Development

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