Sustainable investment evaluation by means of life cycle assessment

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Abstract

Purpose – *Sustainability investors are in need of updated standards, indexes and in general better tools and instruments to facilitate company information on its impacts on people, planet and profit. Such instruments to reveal reliable, independent metrics and indicators to evaluate companies' performances on sustainability exist, however, in research fields that previously have not been used extensively, for instance, life cycle assessments (LCAs). ISO 14001:2015 has implemented life cycle perspective, however, without being explicitly clear on which methodology is preferred. This paper aims to investigate LCA as to improve companies' transparency towards sustainability investors through a literature review on sustainable investment evaluation.*

Design/methodology/approach – *The literature review is conducted through the search engine Google Scholar, which to date hosts the most comprehensive academic database across other databases such as Scopus, ISI Web of Knowledge, Science Direct, etc. Search words such as "Sustainable finance", "Sustainable Investments", "Performance metrics", "Life cycle assessment", "LCA", "Environmental Management Systems", "EMS" and "Environmental Profit and Loss Account" were used. Special journals that publish research on LCA such as* International Journal of Life Cycle Assessment, Journal of Cleaner Production *and* Journal of Industrial Ecology *were also investigated in-depth.*

Findings – *The combination of using LCA in, for instance, environmental profit and loss accounts studied in this paper shows a comprehensive and reliable tool for sustainability investors, as well as for social responsibility standards such as ISO 14001, ISO 26000, UN Global Compact, GIIN, IRIS and GRI to incorporate. With a LCA-based hybrid input-output account, both upstream and downstream's impact on the environment and society can be assessed by companies to attract more funding from sustainability investors such as shareholders, governments and intergovernmental bodies.*

Research limitations/implications – *The literature review is based on publicly disclosed academic papers as well as five displayed company Environmental Profit and Loss accounts from the Kering Group, PUMA, Stella McCartney company, Novo Nordisk and Arla Group. Other company experiences with integration of LCA as a reporting tool have not been found, yet it is not to conclude that these five companies are the only ones to work extensively with LCA.*

Practical implications – *The paper may contribute to the clarification of LCA-thinking and perspective implementation in both ISO 14001 and ISO 26000, as well as in other social responsibility standards such as the UN Global Compact, the Global Impact Investing Networks, IRIS performance metrics, the Global Reporting Initiative and others.*

Originality/value – *The paper is one of the first that evaluates LCA and environmental profit and loss accounts for sustainability investors, as well as for consideration of implementation in social responsibility standards such as the ISO 14001 and ISO 26000, as well as in other social responsibility standards such as the UN Global Compact, the Global Impact Investing Networks, IRIS performance metrics and the Global Reporting Initiative.*

Keywords *Life cycle assessment, Performance metrics, Environmental profit and loss accounting, Hybrid input-output consequential methodology, Social responsibility standards*

Paper type *Literature review*

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Introduction

The Social Responsibility Standard – ISO 26000 defines *sustainable business* as follows[1]:

Sustainable business for organizations means not only providing products and services that satisfy the customer, and doing so without jeopardizing the environment, but also operating in a socially responsible manner.

During ISO 26000's eight years of existence, with the aim of providing a strong standard governing the global market's sustainability issues, social responsibility is still being dealt with primarily by companies and organizations through social benefits rather than environmental or technical solutions to improve world sustainability (Crowther and Seifi, 2018[2]). Furthermore, sustainability financiers such as foundations, investors, internet crowds and government agencies have never been more active in looking for causes, means and specific targets to improve sustainability at the company, national and international levels (Lauesen, 2017).

However, sustainable investments aiming for environmental, social or economic sustainability are in dire need of standardized instruments or reporting tools that can facilitate better information about and evaluation of companies' impacts on people, the planet and profit (Lehner, 2017[3]). These potential sustainability investors lack information from companies regarding their use of sustainable accounting and risk management, which is a deficit in the establishment of an efficient global market linking sustainable capital with appropriate projects (Roundy *et al.*, 2017; Lin *et al.*, 2017; Delai and Takahashi, 2011; Smith and van der Heijden, 2017).

For many years, not only the ISO 26000 Social Responsibility Standard but also other global initiatives such as the UN Global Compact, GIIN (Global Impact Investing Network), IRIS performance metrics, and the Global Reporting Initiative have all tried to establish metrics for sustainable investments to create a vital link between producers, buyers and investors. Research also shows that there is a significant relationship between companies that have adopted sustainability incentives and a positive impact on the shareholders' return (Oshika and Saka, 2017; Lau *et al.*, 2017; Roundy *et al.*, 2017; Sandberg and Holmlund, 2015). These initiatives seem to work effectively in companies' sustainability reporting discourses – i.e. in historic terms looking back upon the companies' previous year of sustainability performance. These metrics, however, do not sufficiently indicate to what degree the companies' future performances will deliver the desired sustainability impact (Aras and Crowther, 2008).

Yet, instruments that can reveal reliable, independent metrics and indicators for evaluating companies' performances and impacts regarding sustainability currently and in the future do exist, especially in other research fields, for instance in life cycle assessment (LCA). Historically, multinational companies and branch organizations have used LCA to enhance their products' trustworthiness in the market regarding their impact on the environment. Many have claimed that LCA has been used as a branding tool to justify buyers' decisions and preferences for certain products. On the other hand, such classic process LCA has been overly expensive for companies to conduct, and therefore it has experienced a decline in utilization as a sustainability metric tool for companies despite its informative value regarding impacts on the environment, society, and the economy (Curran, 2006, np).

LCA has also been used in large multiregional projects – for instance, EU projects or national projects and research funded by state authorities (Schmidt *et al.*, 2010, 2012; Merciai *et al.*, 2013; Høst-Madsen *et al.*, 2014; Grønlund *et al.*, 2015; Wood *et al.*, 2015; Schmidt and de Saxcé, 2016; Merciai and Schmidt, 2017). The tool has been refined and developed with large databases consisting of observational and measured data, so that it nowadays can support companies and investors in less expensive ways, providing objective data that are more valid, trustworthy and independent (Merciai and Schmidt, 2017).

The research question of this paper is thus:

RQ1. How can LCA assist sustainability investors and companies and assist research in exposing relevant data for sustainable finance, risk and accounting?

This paper is a literature review especially aimed at the form and development of LCA and its dispersion among institutions and companies. It shows to what degree the environmental, social and economic dimensions have become integrated and its suitability for sustainability investors' decision-making regarding their choices of investments.

First, the paper reviews the development of LCA, and afterward, the paper reviews the current implementation of LCA regarding sustainable finance among companies. Hereafter, the paper presents four case studies – PUMA, the Stella McCartney Company, Novo Nordisk and Arla Group – and discusses the impact of LCA on the latest development of Environmental Profit and Loss Account (EP&L) and its potential for integrating economic and environmental dimensions of sustainable finance. Finally, the paper discusses the need for integrating the social dimension, which requires further delineation in the years to come and the need for interdisciplinary integration with other sustainability standards on the market.

Methodology

The literature review was conducted through a search for relevant academic papers via the search engine Google Scholar, which to date hosts the most comprehensive academic database across other academic databases such as Scopus, ISI Web of Knowledge, ScienceDirect, etc. (Haddaway *et al.*, 2015). As search words, various combinations of "Sustainable finance," "Sustainable Investments," "Performance Metrics," "Life Cycle Assessment," "LCA," "Environmental Management Systems," "EMS," and "Environmental Profit and Loss Account" were used. Furthermore, specific journal web sites known for their publication of LCA-relevant papers such as *International Journal of Life Cycle Assessment, Journal of Cleaner Production* and *Journal of Industrial Ecology* were used.

Regarding the case studies, search words such as "Life Cycle Assessment," "LCA," "Environmental Management Systems," "EMS," "Environmental Profit and Loss Account," "EP&L" and "EPL" were used on the search engine Google to identify companies that have conducted Environmental Profit and Loss accountings (EP&Ls).

Life cycle assessment – form and development

The form of life cycle assessment

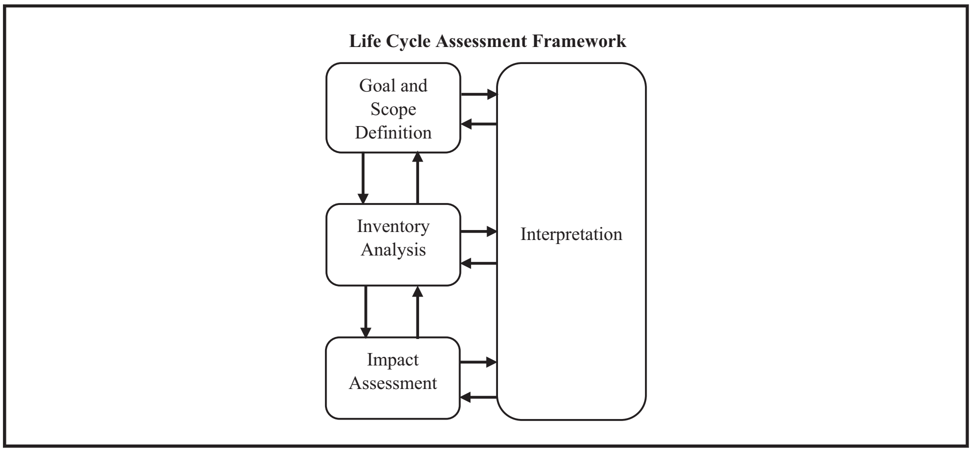
LCA provides a description of companies' products or process systems in terms of their environmental impacts; recently, economic and social impacts have been integrated into this tool as well. LCA provides an impact model with enclosing boundaries based on a functional unit – for instance, 1 m^3 of packed and delivered product, which can be compared with similar functional units of other products or processes (Weidema, 2006; Rebitzer *et al.*, 2004, p. 4).

According to ISO 14040 (2008, p. 4), LCA consists of four phases (Figure 1):

- the goal and scope definition phase;
- the inventory analysis phase;
- the impact assessment phase; and
- the interpretation phase.

Life cycle inventory (LCI) estimates the resource consumption, waste and energy flows and emissions, and sometimes land use and social impacts caused by or connected to a product's life cycle (Schmidt *et al.*, 2015; Ahlgren and Di Lucia, 2014; Rebitzer *et al.*, 2004).

Figure 1 LCA phases according to ISO 14001:2015



Life cycle impact assessment (LCIA) analyses potential impacts from resource extractions, wastes and emissions, which are calculated through various databases with unit impact indicators related to a production or process system. Impact categories are, for example, greenhouse gasses, eutrophication, toxicology and carcinogenetic effect, land use, social impacts, etc.

Life cycle interpretation occurs at every stage of an LCA, especially when two or more product alternatives are compared.

LCA can be assessed in terms of substance or matter impact – for instance, greenhouse emissions measured in kg CO_2 equivalents or even to a finer degree if the analyst wants to know exactly how much of a gas is emitted into the air or substance into the water.

However, with the newer developments within LCA, it has become interesting to evaluate the consequences of different choices and alternatives in terms of costs for society – i.e. in monetary form. The latest databases (e.g. Exiobase, version 3) developed for LCA software nowadays include internationally accepted monetary values of various kinds of pollution, as well as societal impacts in terms of years of human life lost as a consequence of the use of (for example) more intensive mining (see also Pelletier *et al.*, 2015, pp. 80-82; Merciai and Schmidt, 2017).

The development of life cycle assessment

LCA began as a research field in the 1960s based on public concern for finite resources and limitations of raw materials and energy resources (Curran, 2006, np.). In 1969, researchers laid the foundation for the current methods of LCI analysis, where The Coca-Cola Company in the USA was assessed, comparing different beverage containers to determine which had the lowest level of air emissions and affected natural resources the least.

Assessments of other companies elsewhere in the US and Europe followed, and many industrial sectors made their own LCA based on the specific product they produced with the intention of gaining a competitive advantage at the expense of competing products. For instance, Plastics Europe[4] and The European Plastic Pipes and Fittings Association have made LCA data publicly available (Matthews and Fink, 1994), and the European Aluminium Association[5], the Nickel Development Institute, the steel industry IISI, and the European Corrugated Packaging Association (FEFCO) and many others have done so since (Rebitzer *et al.*, 2004).

In the 1980s, this gave LCA a rather negative branding image, because these companies made too-broad marketing claims (Curran, 2006, np.). Therefore, during the 1990s, researchers in the LCA community concluded that both data and documentation validity were crucial. Geographical, temporal, and technological validity were rarely provided at that time, so the Society for the Promotion of Life Cycle Assessment Development initiated the development of a data documentation format, which facilitated the extensive documentation of LCI data for processes and services (Weidema, 1999; Rebitzer *et al.*, 2004). Thus, the LCA methodology was standardized in the International Standards Organization (ISO) 14000 series (1996 through 2002), which remained largely unchanged until 2006 (Weidema, 2014), when the ISO 14040 and 14044 were established as the current standards.

In recent years, distinctions between two types of LCA in particular have been discussed (Ekvall, 2000; Sonnemann and Vigon, 2013; Schmidt, 2015): "attributional LCA" to denote a description of a product system and "consequential LCA" to denote a description of the expected consequences of a change.

Attributional LCA models a system with flows that are "associated with" or "attributed to" the delivery of a product or process in terms of a functional unit. The system is linearly modelled, and scalable regarding the functional unit. However, the flows and processes encountered in an attributional LCA are only those that contribute significantly to the studied product or process and its function. Material and energy flows are followed systematically upstream from the process to the extraction of natural resources and downstream to the final disposal of waste and in this way assumed to be fully elastic (or scalable). Other applications of the product are assumed not to be affected (Rebitzer *et al.*, 2004, pp. 5-6). In this way, attributional LCA can be said to be a "boxed" study, isolated and studied as closely as possible to the impacts directly related to the product or process in question – in other words, an ideal study, which should not be affected by or affect anything other than what is encapsulated in this particular study.

A consequential LCA is a model that views the totality and thus system-wide change in impacts such as pollution and resource flows seen in relation to the functional unit. In this type of modelling, the results depend on the magnitude of the changes in emissions and outlets. A small increase or a reduction in one parameter is described by environmental data for the marginal technologies. This means that consequential LCA encounters all impacts and side effects and is *de facto* "non-boxed." Thus, the results do not scale linearly with the magnitude of the change, and therefore the results are easier to interpret if the functional unit reflects the magnitude of the change investigated. In other words, in a consequential LCA model, the system boundaries depend on how the markets can be expected to react to the change that is studied (Weidema, 2003; Ekvall, 2002; Rebitzer *et al.*, 2004, p. 6).

Throughout the years, multiple databases have been created that cover commonly used goods and services from retail (food and agriculture, fashion and textile, IT and technology), as well as construction materials for the building industry and infrastructure sectors including fuels (fossil as well as renewables) (Merciai and Schmidt, 2017), for example. See Table I for an overview.

These databases offer data per technology process in larger production facilities, both for the attributional and the consequential approach (Konijn *et al.*, 1995; Stahmer *et al.*, 1997; Todd and Curran, 1999; Gravgård-Pedersen, 1999; Nebbia, 2000; Mäenpää and Muukkonen, 2001; Hoekstra, 2005). Regarding modelling methodology, the LCA community has developed different methods to simplify initially very comprehensive and thus expensive and full-process LCA studies, such as:

- the direct (cut-off) simplification of process-oriented modelling;
- LCA based on economic input-output analysis; and
- hybrid LCA, which combines elements of process LCA with input-output approaches.

Table I LCA databases

Meta databases	*Specific databases/add-ons to meta databases*
Ecoinvent, v. 3 (Switzerland)	Arvi Material Value Chain (wood-polymer)
GaBi 2018 (Germany)	Agri-footprint 3.0 (food and agriculture)
Exiobase, v. 3 (EU)	Agribalyse (agricultural products)
U.S. Life Cycle Inventory (USA)	USDA (agricultural products)
Probas (Germany)	Soca (social impacts)
CPM LCA (Sweden)	Needs (energy supply in Europe)
ELCD (EU)	Psilca (social impacts of production)
IDEA, v. 2 (Japan)	Probas (energy, materials, products)
OpenLCA (Germany)	Ökobau.dat (construction materials)
Umberto LCA+ (Germany)	Bioenergie.dat (bioenergy)

Direct cut-off simplifications are recommended to be a vertical cut – i.e. data should be collected for all relevant stages and stressors but in lesser detail (Rebitzer *et al.*, 2004, p. 10). Allocation, on the other hand, where coproducts are cut off, results in failure to maintain mass, energy, and carbon balances, which should therefore be avoided (Suh *et al.*, 2010; Weidema and Schmidt, 2010, p. 192; Pelletier *et al.*, 2015).

Economic LCA-based input-output is an alternative to Process LCA modelling that includes, for example, industry/commodity level input/output (I/O) modelling [Hall *et al.*, 1992; Tukker *et al.*, 2009, 2013; Andrew and Peters, 2013; Lenzen *et al.*, 2012, 2013; Timmer *et al.*, 2015; Organization for Economic Cooperation and Development (OECD), 2016]. I/O databases consist of data from national governmental agencies' statistical departments, which are publicly accessible, and describe the amount (in financial terms) that each industrial sector spends on the goods and services produced by other sectors. Emissions, outlets and other impacts have then been assigned to different commodity sectors. I/O LCAs are thus more complete in widely expanded system boundaries; however, they sometimes lack the detailed level of process specificity of a traditional "Process LCA" (Rebitzer *et al.*, 2004; Merciai and Schmidt, 2017). I/O LCA does not entirely cover a complete upstream system boundary, because national economies may heavily rely upon imports, and it is not checked for sufficient feedstock material to justify production (Merciai and Schmidt, 2017, p. 12).

Hybrid LCA approaches (Bullard and Pillati, 1976; Bullard *et al.*, 1978) overcome this issue, because they combine the advantages of both economic I/O and Process LCA methods (Suh and Huppes, 2002; Rebitzer *et al.*, 2004). In Hybrid LCA, "process analysis is employed when assessing an atypical product that cannot be represented by an aggregated industry sector and thus requires process-specific data, while input-output analysis is used for assessing a typical product that is well approximated by an input-output classification" (Rebitzer *et al.*, 2004, p. 12).

The tiered hybrid input–output method was introduced in the early 1990s, and it covers upstream processes far from the process studied, thus delivering a reference flow for the system studied to process an analysis that covers near-upstream processes more precisely (Rebitzer *et al.*, 2004, pp. 12-13). Hybrid analysis may thus start from the input–output side (Joshi, 2000) and improve process specificity with the use of specifications from a Process LCA (Suh and Huppes, 2002; Suh *et al.*, 2004):

> Hybrid approaches in general provide more complete system definitions while preserving process specificity with relatively small amounts of additional information and inventory data. (Rebitzer *et al.*, 2004, p. 13)

Today, new multiregional hybrid supply-and-use tables provide a tool that is refined and robust for a wide range of analysis of environmental, social, and economic LCAs. They describe the behaviour of producers and consumers in current markets, covering all transactions in the world, and therefore provide scalability from local, national and global accounts in all sectorial spheres, including the availability and sufficiency in feedstock supply for extended productions (Merciai and Schmidt, 2017).

The advantage of this development is that these supply-and-use tables are layered with different units that can be combined into a hybrid mixed-units framework (Hawkins *et al.*, 2007; Majeau-Bettez *et al.*, 2016; Merciai and Heijungs, 2014; Weisz and Duchin, 2006; Merciai and Schmidt, 2017, p. 2). Because these models are typically calibrated with monetary tables, the price levels are reflected in the environmental and social outputs according to the actual market analyzed in the LCA (Merciai and Heijungs, 2014; Merciai and Schmidt, 2017, p. 2).

This makes hybrid supply-and-use tables globally coherent and thus very reliable and relatively much easier to work with than classic process-based LCA, whose detail level depends on a comprehensive knowledge of all details in every product viewed.

Current dispersion of life cycle assessment among companies and industries

While many production industries have embraced LCA as part of their marketing agenda, and some pioneers use it in their overall sustainability policies, investors such as company shareholders, funding governments, public and intergovernmental institutions and the banking sector still do not require companies using LCA to justify their performance and impact on sustainability.

Also, few academic papers have been published concerning the integration of Life Cycle Analysis into sustainable finance. Ravina (2017) claims that traditional risk analysis disregards climate change risks and suggests that carbon footprints should be added either to full Process LCA, Input-Output LCA, or hybrid approaches of the two.

Hoffmann and Busch (2008) have previously urged the integration of LCA in as well debates as reporting practices of sustainable finance. They put forward the dependency on carbon-based materials and energy sources that emit greenhouse gases as major problems of the twenty-first century. LCAs, they conclude, are vital to include, because they can deliver precise results for the life-cycle wide carbon analysis of products and services.

Kuszla and Combe (2012) argue that post-crisis cost-cutting policies in the healthcare system are likely to be ineffective because current valuation models in the financial and accounting fields "do not adequately reflect the evolution of the innovation and production/re-use cycles," i.e. a life cycle approach. Schramade (2016, p. 95) claims that "sustainable investing is much less an application success than a marketing success", and Nielsen and Nørgaard (2011, p. 209) state that investors' current methods of applying environmental, social, and governance data in financial valuations are too simplified and insufficient to capture the additional value.

Clark (2013) explores and discusses the Green Industrial Revolution in the book *The Next Economy*, especially with regard to traditional cost-benefit analysis (CBA) versus LCA in the energy sector. The issue of how to finance technologies to reduce global climate change appears in a different light when using CBA versus LCA (see also Weidema, 2006):

> The CBA model only provides for 2–3-year ROI since that is what most companies (public or government) require for quarterly and annual reports [. . .] LCA covers longer time periods, such as 3–6 years, and within renewable energy systems, some as long as 10–20 years, depending on the product and/or service. Furthermore, LCA includes externalities such as environment, health, and climate change factors, all of which have financial and economic information associated with them. The point is that cost-benefit analyses are limited.

New incentives to promote LCA, however, have emerged with the latest update of ISO 14001:2015 ("Environmental management systems – Requirements with guidance for use"). It incorporates a life cycle perspective at the planning stage prior to making investments. This corresponds with sustainable investors' need for companies to provide information about potential, significant environmental impacts associated with the raw material acquisition, design, production, transportation or delivery, use, end-of-life treatment and final disposal of its products and services (p. 13, 23). ISO 14001:2015 specifies that including a life cycle perspective does not require a detailed LCA; thinking carefully about the life cycle stages that can be controlled or influenced by the organization is sufficient.

For this purpose, Hybrid LCA methodologies offer a tool for systemizing the LCA thinking into a manageable and transparent approach that follows the ISO standards 14040/44 for conducting a trustworthy sustainability assessment. However, the ISO 14001 term "LCA thinking" has created some confusion among auditors regarding what constitutes a true and relevant "LCA thinking" method. For instance, Trinity Consultants in Dallas, TX, interpret the standard in the following way[6]:

> Organizations seeking to align with the new standard must determine precisely what that term "life cycle perspective" means for them. On one hand, the standard makes it clear that a formal life cycle assessment (LCA) is not required; on the other hand, however, language in the standard and associated guidance states that each life cycle stage must be considered [...] There is an implication that an organization must conduct a technical analysis that in some ways resembles a formal LCA in seeking to conform to the new standard.

EH&S Management Consulting Training and Auditing company in Madison, WI[7] notes:

> Based on early experience with 2015 certifications, it is apparent that the certification community has not yet reached consensus on what and how much evidence is required to show conformance with the life cycle perspective requirements.

And from Advisera[8]:

> Even though a formal life cycle assessment is not a requirement [...], understanding the life cycle of your product or service is necessary to get the job done. This needs to include all aspects of your product life cycle such as product packaging, packaging for shipment, and even the final disposal of your product.

Price Waterhouse Coopers[9] states:

> In ISO 14001:2015 the criteria that it used to determine which aspects are significant now has to be documented [...] and the method and the criteria used should provide consistent results.

According to auditors, to live up to the standards mentioned in ISO 14001:2015 (the ISO 14040/44), companies are required to conduct work appropriate to an accreditable LCA, which can be made much simpler than a full LCA – for instance, a hybrid I/O LCA. This is now appearing among large companies who have found a manageable, although still comprehensive, way of implementing the LCA perspective into their environmental management systems with the Environmental Profit and Loss Accounts.

Environmental profit and loss accounts (EP&L) case studies

An EP&L is a company's monetary valuation and analysis of its environmental and/or social and economic impacts seen from a life cycle perspective. EP&L includes all steps contained in an LCA and can be assessed on many levels: from cradle-to-gate, from cradle-to-grave, or even from cradle-to-cradle. It internalizes externalities – i.e. it accounts for impact outside the company – and monetizes the LCA results in terms of cost of business to nature and/or society. It includes the costs of these externalities and shows the direct and indirect impacts on the environment and/or society. All stakeholders can, with the EP&L, see the magnitude of these impacts and where in the supply chain they occur.

The "Profit" in EP&L refers to company activities beneficial to the environment, whereas the "Loss" refers to company activities that have a negative impact on the environment. Companies will often have a net cost to the environment, although these costs are external and thus not something the company will have to pay to society.

Adding the environmental external costs to the current financial costs reflects a more trustworthy picture of the societal and environmental costs of conducting business. It also motivates companies to take more responsibility and aim to reduce environmental impacts. In some countries, for instance, Denmark, some costs are already internalized, such as fees to governments for waste water outlet and waste disposal (Høst-Madsen *et al.*, 2014, p. 10).

The metrics are based on a functional unit as in a traditional LCA. However, in EP&L they are often presented in monetary form, so the company can compare costs and benefits – not only for themselves but for the environment and society as well. An EP&L creates transparency across the company's supply chain and enlightens management's understanding to support its focus on its sustainability efforts. In that way, it can facilitate improving managerial decisions regarding environmental and social risk management and provide a more holistic view of the company's environmental, social and economic performance. As such, an EP&L constitutes not only a key performance index for sustainability investors or finance; it also constitutes a risk analysis and accounting as well as a suitable tool for supply chain management and sustainable investment according to ISO 14001:2015.

In the next section, four case studies of companies that are early adopters of EP&L – PUMA/Kering Group, the Stella McCartney Company, Novo Nordisk and Arla Group – are shown. InTable II is assembled an overview of the highlighted metrics that these companies display on their websites. The references to these metrics are contained in the notes referring to the actual EP&L reports of the case companies.

PUMA/Kering group

In late 2011, the multinational sportswear and fashion company PUMA, owned by the Kering Group, was the first global company to declare an EP&L. It was conducted by PricewaterhouseCoopers and Trucost and published in 2012, showing that PUMA's environmental and social costs amounted to £124m[10] (EUR 145m) from emissions of greenhouse gasses, water usage, air pollution, land use and waste. Despite the resulting hard work in all supply chains of PUMA, the company has continued to publish annual EP&Ls since then. Its parent company Kering has, furthermore, implemented EP&Ls throughout all of its other companies. To create an EP&L, Kering explain their methodology in seven steps[11]:

1. decide what to measure;
2. map the supply chain;
3. identify priority data;
4. collect primary data;
5. collect secondary data;
6. determine valuation; and
7. calculate and analyze the results.

These steps follow an I/O LCA, which includes monetary valuation on environmental as well as societal impacts. The Kering Group's 2016 EP&L[12] reveals that most impacts come

Table II Highlighted results from case study EP&Ls

Metrics / *Company*	*PUMA*	*Kering group*	*Stella McCartney company*	*Novo nordisk*	*Arla group*
Year of report	2010-2016	2012-2016	2013-2015	2011	2014
Publication year	2011-2017	2017	2016	2014	2016
Output metrics	Greenhouse gasses[a] Water consumption[b] Water pollution[c] Air pollution[d] Land use[e] Waste[f]	Greenhouse gasses Water consumption Water pollution Air pollution Land use Waste	Greenhouse gasses Water consumption Water pollution Air pollution Land use Waste	Greenhouse gasses Water consumption Air pollution Land use change	Greenhouse gasses Water consumption Air pollution Land use change
Impact (MEUR)	€145m (2010) €457m (2016)	€857m (2016)	€5.5m (2015)	€223m (2011)	6 different methods are evaluated in the report. Impacts range from €1,840m to €5,850m depending on methodology used
Highest impact	Use of leather	Use of leather	Use of cashmere	Use of energy	Use of energy, ammonia and land[g]
Reduction goal 1	Material use	Material use	Material use		
Reduction goal 2	Energy use	Energy use	Impact from all materials		
Optained goal 1 reduction(s)	Yes – in production intensity (impact per volume)	Yes – in production intensity (impact per volume)	From 42% – 24% impact from cashmere	General impacts are published in company sustainability reports	General impacts are published in company sustainability reports
Optained goal 2 reduction(s)	An impact reduction of 7.5% of revenue from 2013 to 2016 (not related to initial year of 2010)[10]	An impact reduction from €77 to €69 per €1000 revenue from 2012 to 2016	11.82 €/kg (2013) 9.76 €/kg (2014) 7.69 €/kg (2015) = 35% reduction in all materials		
Continued EP&L	Yes	Yes	Yes	No – pilot project	No – pilot project

Notes: [a]CO_2, N_2O, CH_4, CFCs, etc. See http://about.puma.com/en/sustainability/environment/environmental-profit-and-loss-account; [b]Consumption in m^3; [c]Heavy metals, nutrients, toxic compounds; $dPM_{2,5}$, $p.m._{10}$, NO_X, SO_X, VOCs, NH_3 [e]Area of tropical forest, temperate forest, inland wetland etc.; [f]Hazardous and non-hazardous; [g]Depending on method

from the company's use of leather, which is also PUMA's primary raw material for creating sports shoes and footballs. Furthermore, the EP&L shows where the impact is highest – in China, where most of the manufacturing takes place. Because of the results of the EP&L, Kering Group explains that the company wants to focus on reducing its impacts from material and energy consumption, which are the two largest sources of environmental impact.

Kering have published an extensive range of reports on their website addressing various nuances of their impacts seen in the EP&L reports[13]. The many academic and public debates about social impact in the fashion and textile segment have framed much of the sustainability and corporate social responsibility (CSR) discussion recently. PUMA have, in addition to the Kering Group, its own sustainability report, in which human rights are mentioned, and the social dimension is also included in the EP&L based on I/O LCA.

PUMA explain their choices and methodologies in their EP&L:

> This economic valuation of PUMA's environmental impact does not affect our net earnings but provides us with a wake-up call and the urgent need to act upon it. These findings transparently reveal where we have to direct our sustainability initiatives in order to make real improvements in reducing our footprint. (PUMA, 2011, np., Foreword by Jochen Zeitz)

PUMA/Kering Group have not published full EP&Ls in the ensuing years but rather only highlights. PUMA's EP&L is on the webpage of the Global Leadership Award, where PUMA/ Kering Group achieved a prize in 2014 and thus uploaded documentation and explained the methodology in detail.

Stella McCartney

The Stella McCartney Company are also a part of the Kering Group as a 50/50 joint venture. They published their first EP&L in 2016[14], covering their 2015 sales year. The company have conducted EP&Ls since 2013 and published the following on their website in 2016:

> After three years of working with our supply chains and using the EP&L methodology, we decided that it was time to share the results of our EP&L. With our 2015 results we feel that we have a complete picture of our impacts across our supply chain. This is why we have made the decision to release these results.

The report frames a few representative result graphs similar to the graphic form presented by the Kering Group. However, this report includes all years from 2013 to 2015 to show the company's improvements in reducing their impacts on the environment at 35 per cent per kg material used. The reduction stems from changes the company have made in how and where they source their raw materials (McCartney, 2016, p. 1).

Furthermore, the Stella McCartney Company explains the overall methodology behind their EP&L:

> [These] data [are] then combined with secondary data from Life Cycle Assessments (LCAs), Environmentally-Extended Input-Output (EEIO) models and industry statistics.

For further explanation, the Stella McCartney Company refers to the Kering Group Web page.

The PUMA results showed that leather is a major environmental impact, which the Stella McCartney Company, with their vegetarian philosophy and focus on synthetic fabrics, avoid. The Stella McCartney Company explains (2016, p. 5) how the management has changed decisions based on their EP&L as well as PUMA's:

> In 2014 cashmere accounted for 42 per cent of our environmental impact at the raw material stage, despite making up only 0.1 per cent of our material usage. In 2015 the percentage decreased to 24% because we had begun to use regenerated cashmere. During 2016 we replaced all of our virgin cashmere with regenerated cashmere, and we expect to see even more significant reductions in the 2016 results.

The high environmental impact of cashmere is primarily due to the small quantities of fibers that can be harvested from a goat per year and the land needed for the goats to live on (p. 7).

Novo Nordisk

The multinational pharmaceutical company Novo Nordisk has been the fulcrum in a pilot project, publishing its 2011 EP&L[15] in 2014. The accounting was conducted by the Danish consultancy companies NIRAS and 2.-0 LCA Consultants and the British TruCost [16] and financed by the Danish Environmental Authority for testing and development of an EP&L concept involving the Danish industry[17].

The Novo Nordisk EP&L consists of the seven-step method also outlined under the PUMA/ Kering Group earlier, and it is, similarly, a comprehensive cradle-to-gate I/O LCA-based calculation. Yet, the distribution portion is not included, nor are the impacts relating to in-use or end-of-life impacts of products. In line with the PUMA EP&L bottom line, the results show that Novo Nordisk impacts the environment and society at €223m, of which greenhouse gas expenses constitute the majority with 77 per cent of these costs.

The partners behind the data collection, LCA computation, and reporting reveal that such a full-scale LCA of a large company like Novo Nordisk is estimated to take between 12 and 18 months to perform (Høst-Madsen, 2014, p. 12), which would suggest a similar effort for the PUMA initial EP&L.

This scale of work is, obviously, not conducted each year, either by the PUMA/Kering Group, Stella McCartney, Novo Nordisk or others – it is a baseline EP&L, after which the companies can choose to report changes to the baseline in subsequent years. Or – as suggested in the ISO 14001:2015 – companies can settle for evaluating investments up front and are not required to do a full LCA for their EP&L on a yearly basis.

In contrast to the PUMA/Kering and Stella McCartney EP&Ls, the Novo Nordisk EP&L report has an extensive methodology description including a high content of primary data (75 per cent), highly detailed in-depth results presentation, no sales or branding statements, and objectivity in its language:

> Though Novo Nordisk provided water consumption data and energy consumption data for its directly owned sites, similar data [were] unavailable for outsourced operations, which are responsible for the production of a significant part of all Novo Nordisk devices. The impacts associated with outsourced facilities have been quantified using EIO modelling and estimations based on available secondary data. (Høst-Madsen *et al.*, 2014, p. 25)

The Novo Nordisk EP&L report also reveals that the majority of the company's environmental costs (70 per cent) lie outside its direct control. Although Novo Nordisk already has numerous initiatives to reduce their environmental impact, the supply chain needs to be further investigated for Novo Nordisk to reduce its vital impacts on society and the environment (p. 29).

Furthermore, as with the previous examples from the PUMA/Kering Group and Stella McCartney, all the companies should consider whether the Profit & Loss accounting for the remaining bottom line – social impacts – should be assessed to complete an all-encompassing profit and loss account.

Arla

A similar EP&L report on the Danish dairy company Arla, conducted in 2016 by the 2.-0 LCA Consultants, is a more comprehensive EP&L than the above cases. The Arla EP&L was financed by the Arla Group and, to a lesser extent, cofinanced by the Danish Environmental Ministry (DK EPA). In the Arla EP&L, different methodologies have been used and compared, which gives a more nuanced but also diverse impact results. For instance, both the attributional as well as the consequential models are calculated in the LCA, and different value-input methods have also been tested: the Stepwise method, the Danish Environmental Ministry's recommended valuation and TruCost's valuation.

The choice of method is not without impact on the results; in other words, the total results in environmental costs depend on which valuation method is used. See Table III. The Stepwise method gives generally high contributions regardless of whether the EP&L is calculated with the attributional versus the consequential method. The TruCost method, on the other hand, gives generally very low impact results, whereas the Danish EPA falls in between.

This illustrates that EP&Ls cannot be compared, because the choices, methodologies, and valuation methods differ. In the preceding cases, TruCost methods have likely been used, although none of those reports explicitly mention it. However, as TruCost has been a partner in all the former reports, it is assumed that their valuation method has been used for the

Table III Explanation of monetarized results obtained by using different methods

Method	Results (MEUR)	Explanation
Stepwise		
Consequential LCA	5,850	High contribution: GHG emissions, ammonia and nature occupation Low contribution: None
Attributional LCA	4,984	High contribution: GHG emissions, ammonia Low contribution: Nature occupation
Danish EPA valuation		
Consequential LCA	2,900-4,270	High contribution: Ammonia
Attributional LCA	2,240-3,710	Low contribution: GHG emissions (nature occupation is not valuated)
TruCost		
Consequential LCA	1,840-1,910	High contribution: GHG emissions
Attributional LCA	2,370-2,430	Low contribution: Ammonia (nature occupation is not valuated)

Notes: The intervals represent different versions of the valuation methods. Adapted with source reference as permitted from https://www2.mst.dk/Udgiv/publications/2016/05/978-87-93435-75-9.pdf. Schmidt and de Saxcé (2016, p. 2, 18)

calculation of the PUMA/Kering Group, Stella McCartney and Novo Nordisk EP&Ls. Therefore, the robustness of data in an EP&L rely on the physical units rather than the financial costs, since they depend heavily on which valuation method has been used (Schmidt and Saxcé, 2018, p. 18). Thus, a request for more scientific consensus on how to report, which methodology suits an EP&L best, and how to monetarise environmental impacts are vital for sustainability research as well as for sustainability investors.

Findings and discussion – the effect and suitability of life cycle assessment for sustainability investors

Although an EP&L is based on static LCA simulation models, it represents several company activities such as production processes, transport, or retail, which are relevant for sustainability investors. However, the choices and assumptions made during the LCA modelling, such as system boundaries, what processes to include, and which valuation data to use, are often crucially decisive for the results of an LCA study (Rebitzer *et al.*, 2004). Therefore, it is very important that future EP&Ls include a much more detailed methodology description, including the scope and goal of the assessment.

With its broad upstream and downstream system boundaries, I/O LCA provides a comprehensive modelled supply chain but with less detailed outputs. Process LCA provides a more detailed analysis fit for comparing different products or designs; however, it does not include the wider supply chain to the same degree that I/O LCA does.

On the other hand, when sustainability investors are looking for the overall environmental impact of a company, with process or system comparisons between different options on a regional, national or international level, the I/O LCA-based EP&L is a suitable option.

Therefore, regarding social responsibility standards such as ISO 26000, the UN Global Compact, GIIN, IRIS and GRI, appropriate data are already available through LCA databases, etc. The results of companies' LCA-based EP&Ls can be used for sustainability investors and sustainability indexes without imposing costly and time-consuming modelling upon the companies conducting them. Newer LCA databases (e.g. ExioBase, v.3; the SoCa add-on to EcoInvent v.3.3, and Social Hot Spot) also have I/O data on social consequences of processes (Weidema, 2006, 2014; Grønlund *et al.*, 2015; Wood *et al.*, 2015). Social or human impact from industries and transportation can be measured, for instance, in disability-adjusted life years (DALY) characterisation factors or as quality-adjusted life years (QALY) impacts on human well-being for a population group.

However, concerning the ISO 14001:2015 standardization, a consensus regarding to what degree and depth LCA should be assessed by companies being certified still needs to be made. This paper suggests that I/O LCA-based EP&Ls may accomplish this task in a non-exhaustive, cost-effective and relatively short time frame, especially if the company already has impact data from their own production measured for sustainability or CSR reports. The additional work lies in merging these already-known data from the CSR report with the external data, which can be found in various statistics from I/O databases, and together these can form the basis of an EP&L accounting.

Conclusion and future research

The answer to *RQ1* is that LCA can assist sustainability investors and companies as well as it can help research in exposing relevant data in ways that no other instrument or tool has shown so far. LCA needs to be assessed in companies' EP&Ls so investors can obtain a transparent valuation tool for their sustainable investments. For this purpose, valuation methodologies must be chosen very carefully and reported transparently and in depth in company EP&Ls.

ISO 14001:2015 can benefit from integration of I/O hybrid LCA and thus assist sustainability investors in using a standardized, and at the same time a simpler and cheaper, way to monitor their sustainable investments than conducting a full LCA. Different ways to work with this should be published, discussed and evaluated to reach a consensus of minimum requirements according to the ISO 14001:2015, as no such consensus exists today.

Future refinements of how to report, which methodology suits an EP&L best, how to monetarise environmental impacts, and, especially, how to enlarge the knowledge and databases of social LCA is vital for research as well as for investors in sustainable finance. There are many arguments for and against monetarization of such impacts and the value that is ascertained to especially impacting versus protecting the environment as well as social issues. These need to be further discussed and integrated into the LCA debates and databases in a way that makes it transparent and trustworthy in terms of choices that can be made when conducting an LCA.

Notes

1. Available at: www.iso.org/news/2011/03/Ref1558.html
2. Available at: www.emeraldgrouppublishing.com/products/journals/call_for_papers.htm?id=7721
3. Available at: www.acrn.eu/ssfii/
4. Association of Plastics Manufacturers in Europe (APME).
5. Available at: www.aluplanet.com
6. Available at: www.trinityconsultants.com/news/ehs-management/iso-14001–2015-implementation-challenges–addressing-life-cycle-perspective
7. Available at: http://envcompsys.com/blog/iso-140012015-life-cycle-perspective/
8. Available at: https://advisera.com/14001academy/blog/2016/03/21/how-does-product-life-cycle-influence-environmental-aspects-according-to-iso-140012015/
9. Available at: http://auditortraining.pwc.com.au/iso-140012015-what-will-your-auditor-be-asking/
10. Available at: www.huffingtonpost.co.uk/2011/11/18/puma-jochen-zeitz-environment-footprint_n_1101126.html
11. Available at: www.kering.com/en/sustainability/methodology
12. Available at: www.kering.com/sites/default/files/kering_group_2016_epl_results.pdf
13. Available at: www.kering.com/en/sustainability/media-library
14. Available at: http://cdn3.yoox.biz/cloud/stellawp/uploads/2016/09/SMC-EPL-Final-Report-2015.pdf

15. Available at: www2.mst.dk/Udgiv/publications/2014/02/978-87-93178-02-1.pdf
16. British TruCost was also involved in the making of the PUMA/Kering EP&L.
17. Available at: www.niras.dk/nyheder/nyt-vaerktoej-goer-miljoebelastning-op-i-kr-og-oere/ (in Danish).

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