Journal of Cleaner Production 230 (2019) 378–382

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Short communication

The role of life cycle engineering (LCE) in meeting the sustainable development goals – report from a consultation of LCE experts

Alexis Laurent [a, *], Christine Molin [a], Mikołaj Owsianiak [a], Peter Fantke [a], Wim Dewulf [b], Christoph Herrmann [c], Sami Kara [d], Michael Hauschild [a]

[a] Quantitative Sustainability Assessment Group, DTU Management, Technical University of Denmark, Produktionstorvet 424, 2800, Kgs. Lyngby, Denmark
[b] KU Leuven, Mechanical Engineering Department, Celestijnenlaan 300, Heverlee, 3001, Belgium
[c] Chair of Sustainable Manufacturing and Life Cycle Engineering, Institute of Machine Tools and Production Technology, Technische Universität Braunschweig, Germany
[d] Sustainable Manufacturing & Life Cycle Engineering Research Group, School of Mechanical & Manufacturing Engineering, The University of New South Wales, Sydney, Australia

ARTICLE INFO

Article history:
Received 5 March 2019
Received in revised form
8 May 2019
Accepted 12 May 2019
Available online 13 May 2019

Keywords:
Absolute sustainability
Interactive session
Life cycle assessment
Manufacturing
SDG
Sustainable production and consumption

ABSTRACT

Life cycle engineering (LCE) targets product development and manufacturing activities in a life cycle perspective, with the aim to create more sustainable solutions. Coined approximately 30 years ago, it was adopted by the International Academy for Production Engineering (CIRP, from the French title), which established annual conferences on life cycle engineering to further develop the concept and its operationalisation. With the recent advent of the United Nations' Sustainable Development Goals (SDGs), engineering is now provided with specific targets to steer societies towards sustainable production and consumption. But how can LCE *contribute to meeting the UN SDGs?* Here, we report on a consultation process conducted as part of the 25th CIRP LCE conference, organised in Copenhagen, DK, in 2018. Approximately 175 participants reflected on a list of ten pre-identified challenges for implementing the SDG agenda that LCE could help tackle, and were solicited to propose solutions. A total of 118 solutions were proposed, and the main messages and recommendations are summarised and reported in the paper. Overall, they voice the need for stronger action from academia (e.g. research needs related to addressing trade-offs across SDGs), business and governments (e.g. transparent and harmonised reporting on sustainability performances, internalisation of external costs) and society at large (e.g. consumer behaviour, role of education).

1. Introduction

The term of "Life Cycle Engineering" (LCE) can be traced back to the late 80s/early 90s, where it was coined by academic leaders in product design and manufacturing communities, who recognised the need for developing a "new industrial culture" of sustainable industrial production (Fabricky, 1987; Keys, 1990; Keoleian and Menerey, 1993; Alting and Jørgensen, 1993). As a result, the International Academy for Production Engineering, also known by the acronym CIRP (the acronym derives from the original French name for the academy), adopted the life cycle engineering concept in 1992, establishing an official LCE working group, and one year later the first international CIRP Life Cycle Engineering conference was held.

Life cycle engineering was then identified as a key element in the process to assess and improve the environmental, occupational health and resource consequences of products and services throughout all life cycle stages, i.e. from extraction of raw materials to final disposal (Alting and Jørgensen, 1993; Alting and Legarth, 1995). A more comprehensive definition of LCE was later proposed by Jeswiet et al. (2003) as "the engineering activities which include the application of technological and scientific principles to manufacturing products with the goal of protecting the environment, conserving resources, encouraging economic progress, keeping in mind social concerns, and the need for sustainability, while optimizing the product life cycle and minimizing pollution and waste." Hauschild et al. (2017) challenged that definition, recommending the refocusing on the environmental dimension of

* Corresponding author.
E-mail address: alau@dtu.dk (A. Laurent).

https://doi.org/10.1016/j.jclepro.2019.05.129
0959-6526/

sustainability and introducing an absolute sustainability perspective to change the focus of the LCE discipline from eco-efficiency to eco-effectiveness towards a sustainable consumption and production. Over the last three decades, methods and tools have been developed in support of LCE (Herrmann et al., 2014), including life-cycle-oriented methodologies, such as life cycle assessment (LCA) or life cycle costing, as well as life-cycle stage-oriented methodologies, such as green material selection or some 'Design for X' approaches (X = disassembly, recycling, etc.).

The relatively recent United Nations' Sustainable Development Goals (SDGs) allow LCE to focus and to derive areas of action. Set by the United Nations General Assembly in 2015 and adopted by all member states, the SDGs are a collection of 17 goals, associated with 169 targets, which provide a 2030 agenda for reaching sustainable development with regard to economic, social and environmental issues (UN, 2015; ICSU/ISSC, 2015). To avoid problem shifting most these goals require to be addressed with a life cycle perspective. In addition, several goals can be directly linked to sustainability in manufacturing, for example SDG no. 12 "Ensure sustainable consumption and production patterns" (UN, 2015; ICSU/ISSC, 2015). However, the broader perspective on "*How can LCE contribute to meeting the UN SDGs?*" still remains to be addressed.

Previous attempts to relate the SDGs to life cycle engineering include Schroeder et al. (2019), who reviewed circular economy (CE) practices and linked them to SDGs to identify opportunities, Juraschek et al. (2018), who explored potential contributions of urban factories to the SDGs, Secher et al. (2018), who proposed linkages between LCE and SDGs for small and medium enterprises in the building material sector, or Pedersen (2018), who reported feedback from the utilisation of SDG in business strategy with the case of enzyme production. Albeit laudable, none of the above studies relates LCE to SDGs in a broad context to identify potential challenges and solutions in using LCE to help meet the SDGs.

We took the opportunity of the 25th CIRP Life Cycle Engineering conference, organised in 2018 to bring this question on the agenda (Hauschild et al., 2018). Through the design and conduct of an interactive session, we aimed to (i) map which SDGs could be relevant to manufacturing industry, (ii) identify a set of key challenges for implementing the SDG targets in manufacturing industry, and (iii) discuss possible LCE-related solutions to overcome these challenges based on the collected inputs at the conference session. Here, we report the main findings from that consultation process. As part of the reporting, we also describe the methodology in detail in the hope that it may be of use to others inside and outside the LCE field wishing to identify challenges and solutions for implementing the SDG agenda.

2. Methodology

The interactive session was organised as part of the scientific programme of the 25th CIRP LCE conference, organised from 30 April to 2 May 2018 in Copenhagen, Denmark. The conference itself gathered 246 participants under the conference theme of "Advancing Life Cycle Engineering to meet United Nation's Sustainable Development Goals" (proceedings in Procedia CIRP 69; Laurent et al., 2018). The interactive session addressed the overarching question: "*How can Life Cycle Engineering contribute with solutions and tools to meet the challenges in implementing the UN SDG targets?*" Details of the methodology and the steps followed before, during and after the conference session (from preparation to result analysis) are documented in Supplementary Information (SI); a brief summary is provided here.

Based on a review of the SDGs made by the session organisers (i.e. authors of this paper), a total of 33 SDG targets were identified as relevant to the manufacturing industry (Supporting Table S1). As part of an internal discussion, ten challenges were identified in the achievement of these 33 targets –see Table 1. The session design was then planned so that the participants would be presented with these 10 challenges and discuss potential solutions to overcome one or more of them, according to their own main interests. Approximately 175 participants attended the session. The participants were asked to randomly form groups of 3–5 members as seated and report their potential solutions back to the session organisers. This reporting was done via a transparent and easy-to-use online tool (padlet.com), representing a free wall for real-time participation and assessment of multi-person inputs. In the session, groups could address any or all of the 10 challenges as they wished. The tool ensured full anonymization of the submitted inputs, i.e. without tracking of any name or other personal information of any individual or group submitting one or more solutions to the wall.

3. Results and discussion

3.1. Overall survey results

About 175 participants attending the session, proposed a total of 118 solutions. For data protection reasons, only aggregated results and findings are provided in the following (no reporting of individual answers). Fig. 1 shows the number of solutions for each of the challenges listed in Table 1. It should be noted that many of these solutions have the nature of additional challenges or sub-challenges rather than operational solutions (difficult to prevent in surveys with open questions). Nonetheless, they are in the following referred to as "solutions".

When reading and interpreting the survey results, some characteristics of the surveyed participants should be kept in mind: (i) more than 90% of the participants come from high income countries (i.e. industrialised countries in Europe and North America, mainly); (ii) ca. 87% of the participants are from academia, with only 9% from industry/consultancy and 2% from authorities; and (iii) a large proportion of the participants represent the fields of LCA and/or manufacturing industry, and are naturally prone to reflect their respective fields when solicited.

Fig. 1 shows that the number of proposed solutions per challenge varies strongly from one challenge to another. This may be explained by a large representation of experts in the fields covering a specific challenge or by the varying difficulty of the challenges. Therefore, the observed distribution does not necessarily indicate that one challenge is more important or relevant than another. These biases may explain some of the observed trends in Fig. 1; for example, the emphasis on Challenge 7 on engineering education may be partly due to the large representation of academics in the session.

3.2. Key messages

Key findings from the session outcomes were identified and analysed; they are summarised in the following (in no specific order):

- *Relevance of including both producer and consumer perspectives.* In spite of a strong representation of the manufacturing research community (within academia and industry), the general trends from Fig. 1 suggest that the achievement of the SDGs must be addressed by taking both producer and consumer perspectives into consideration (visible in answers to Challenges 1 and 3–6 that cover achievement of sustainable manufacturing and consumption; data not shown).

Table 1
Pre-identified challenges that LCE could address to contribute implementing the SDGs (formulated as preparation for the interactive SDG session at the CIRP LCE Conference 2018, Copenhagen, DK).

	Challenges	SDG targets addressed	Challenge context
1	Ensure a combined optimisation of all relevant SDGs for manufacturing (trade-offs)	All preselected SDGs and their corresponding targets as reported in Supplementary Information (SI)	Trade-offs occur when a product or technology, which helps meeting specific targets, compromise other targets of the same or another goal. A challenge is both to quantify and weight such trade-offs
2	Translate absolute environmental sustainability limits into targets for companies or products	3.4; 3.6; 7.3; 12.3 [a]	Some SDGs use absolute environmental sustainability limits (e.g. reduce by one third premature mortality) when defining underlying targets, but it is not clear what these absolute limits actually mean for individual products or companies
3	Focus business and product development on the achievement of SDGs	All shortlisted SDGs and corresponding targets as reported in Supplementary Information (SI)	To meet SDGs, product development should focus not only on designing better products (in terms of quality, efficiency, revenue, etc.) but also on designing more sustainable products.
4	Decouple economic growth from environmental degradation	3.4; 3.6; 3.9; 6.3; 6.6; 13.1; 14.1; 14.2; 14.3; 15.1–15.5	Economic growth has happened at the expense of the environment and it is a challenge to ensure economic growth without increasing pressure on the environment beyond sustainability limits
5	Promote sustainable consumption behaviour	12.2; 12.3; 12.5	Citizens can play an important role in contributing to meeting the SDGs, in particular SDG12, but this may require changes in their way of living
6	Develop manufacturing for a circular economy that is sustainable in absolute terms	12.2; 12.3; 12.4; 12.5	Circular economy has the potential to make manufacturing more sustainable, but it can be a challenge to identify whether it can make manufacturing sustainable in absolute terms when absolute environmental limits are considered
7	Integrate “engineering for sustainable development” centrally in engineering curriculum	12.2; 12.3; 12.4; 12.5	Engineers should know about how to address sustainability when developing new products or technologies
8	Link existing sustainability tools in industry (e.g. eco-design, LCA) with SDG framework	9.4; 12.2; 12.3; 12.4; 12.5	Assessing and managing sustainability requires taking a life cycle perspective and existing tools, including LCA, could be used to address the SDGs
9	Make addressing environmental and social challenges the ordinary way of engineering	All preselected SDGs and corresponding targets as reported in SI	Engineers should design new products or technologies with sustainability as guiding principle rather than an add-on
10	Make the International Academy for Production Engineering (CIRP) an ambassador of sustainable engineering [b]	All preselected SDGs and corresponding targets as reported in SI	To address SDGs relevant to manufacturing engineering, support from influential and recognised bodies, like CIRP, with many LCE engineers on board, is probably indispensable [b]

[a] Only targets, where limits are clearly defined are listed here, hence excluding those using the terms “substantial reductions”, “sustainable …” without further specifications.
[b] Pre-identified challenge 10 is mainly motivated by the context of the CIRP conference. We fully acknowledge that, although the CIRP community should play a key role, the relevance and influence of LCE in contributing to meet the SDGs extend beyond the CIRP community, and others stakeholders in the field of LCE should be key actors in this effort.

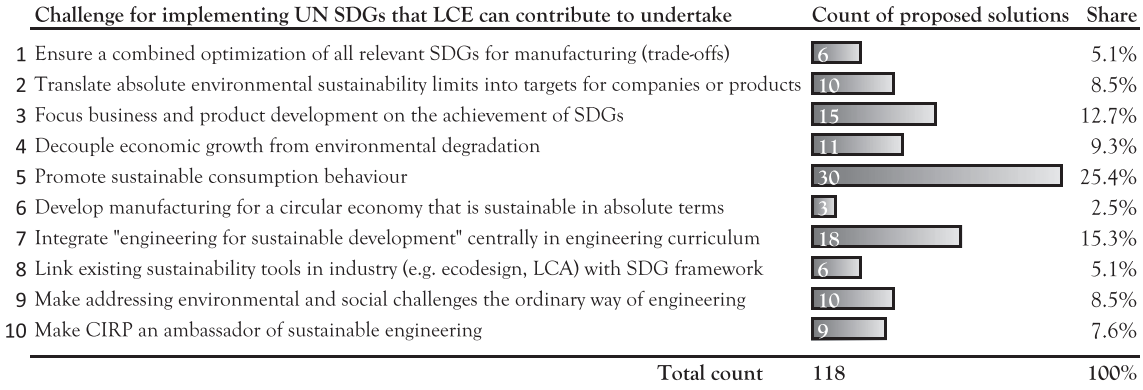

Fig. 1. Distribution of proposed solutions that the LCE field can bring to meet pre-identified challenges for implementing the United Nations Sustainable Development Goals (collected during the interactive SDG session).

- *Motivation for companies and customers to move towards SDGs.* Different solutions were proposed to address Challenge 3 (enhancing business perspective to move towards SDGs) such as establishing a reward system (e.g. lower taxation schemes for laudable companies) or ensuring a public recognition (public disclosure of actions towards SDGs). A parallel is observed in Challenge 5 (influencing consumer's behaviour), where price incentives for the consumers (e.g. lower taxation) were suggested as a possible solution.
- *Need to develop key performance indicators (KPIs) for SDGs for companies and products.* To monitor the progress towards the SDGs and communicate on SDG performances, an evaluation system with quantifiable metrics and based on life cycle perspective needs to be developed, as suggested in solutions to Challenges 3 and 4 (addressing business perspective to achieve SDGs and decoupling of economic growth from environmental impacts, respectively). To be operational and effective, such a system should be recognised by all stakeholders. The development of such KPIs can be inspired from the development and application of nationally-determined contributions, which are actions planned by national authorities to undertake their engagement towards the Paris Agreement and can be defined at specific levels of technologies or sectors (Vázquez-Rowe et al., 2019).

- *Internalisation of environmental impacts in product/production costs.* This is not a new call as the need for internalisation of externalities (considering the entire life cycle of products), as repeated here in solutions to Challenges 4 and 5 (decoupling of growth from impacts, and promoting sustainable consumer's behaviour), has been identified in many previous fora and in the literature (e.g. WBCSD, 2010; van den Bergh, 2010). However, its implementation in practice has yet to be attempted.
- *Increasing transparency of sustainability performances of companies and their products.* Several solutions to Challenges 3 and 5 on business and consumer perspectives as well as to Challenge 9 on the routine integration of environmental and social perspectives in manufacturing engineering emphasise the need to increase the communication and transparency of such reporting, often calling for mandatory disclosure of sustainability performances. At the product level, environmental labelling may be used for this (Frydendal et al., 2018), while corporate sustainability reports could be a relevant communication route for companies and organisations (Stewart et al., 2018). Transparent communication however presents challenges, e.g. selection and types of indicators to use and harmonisation issues.
- *Defining absolute thresholds for raw materials adapted to company or product levels.* In addressing Challenge 6 (defining absolute sustainability thresholds for manufacturing through circular economy), which received the fewest answers (2.5% with 3 answers), the need to define such thresholds was raised. This is aligned with the general need to determine absolute thresholds from local to global scale for impacts on ecosystems, resources and human health and to translate them at lower levels (products, sectors, organisations, individuals, etc.) based on allocation principles (Kara et al., 2018; Laurent and Owsianiak, 2017; Bjørn et al., 2018; Ryberg et al., 2018; Fantke and Illner, 2019). Difficulties in identifying and developing approaches to do so and in the ensuing need to find consensus remain to be overcome, as reflected by the lack of consistent solutions to Challenge 2 on defining absolute thresholds for companies and products (data not shown).
- *Need for developing priority or weighting schemes to address SDG trade-offs.* This proposal was raised as a solution to Challenge 1 on achieving a combined optimisation of all relevant SDGs, and can be linked to proposals in addressing Challenge 8 to map cause-effect mechanisms within and across SDGs and potentially linking them to LCE indicators, e.g. covered in life cycle impact assessment (LCIA) methods. Such linkage could help solve some of the trade-offs between SDGs. As an example, reducing biodiversity loss, which may be captured as one indicator in LCIA, would contribute to addressing several SDGs, e.g. no. 13 (tackling climate change), 12 (responsible production and consumption), 14 (life below water), etc. Recent initiatives and research projects have already been initiated in this direction, including for example research plans to link SDGs to LCIA frameworks (part of project initiated by UN Environment's Life Cycle Initiative; Weidema et al., 2018) or research exploring the connection of the broader life cycle sustainability assessment framework with the SDGs (Wulf et al., 2018; Kühnen et al., 2019).
- *Importance of education.* In terms of number of proposed solutions, Challenge 7 on improving engineering curriculum is in the top-3 among the challenges (attracting 15% of all answers, Fig. 1). Three main propositions were made, confirming recommendations in published literature (Cosme et al., 2018): (i) the education and motivation for sustainable development could start before the engineering curriculum, e.g. from the primary school education; (ii) the inclusion of environmental sustainability topics could be made mandatory in engineering education programmes; and (iii) teachers in high-level education systems (but also at primary and secondary levels) should be motivated and trained to address environmental sustainability in a qualified manner in their courses.
- *Increasing the relation to environmental sustainability in the field of engineering science.* As part of Challenge 10 to strengthen the role of CIRP in sustainable engineering, some answers reflected on the possibility to impose authors of CIRP scientific journals to relate their findings to environmental sustainability wherever relevant, when describing new technologies or manufacturing/disposal processes. This provocative proposal could be extended beyond the CIRP community to the field of engineering at large. One could thus envision scientific journal editors encouraging authors of engineering-related studies to explicitly link their research to environmental sustainability in their manuscripts.

4. Conclusions and recommendations

To the knowledge of the authors, this kind of survey exploring solutions that LCE can bring to address challenges in implementing the SDGs is the first of its kind. Out of the highlighted key messages, many raise new challenges and call for immediate actions from actors at all levels, calling for academia to address major research gaps (e.g. practical integration of absolute perspective into LCE, addressing of trade-offs across SDGs and linkage to LCIA), requiring more effective business and governmental actions (e.g. transparent and harmonised reporting on sustainability performances, internalisation of external costs) and, in a broader perspective, pleading for changes in modern societies (e.g. consumer behaviour, role of education). Among those, the influence, which LCE can have on some societal and economic challenges, may not always be evident, e.g. changes in consumption behaviour. Although the demonstration of such influence is beyond the scope of this reporting, the authors believe that LCE can play a role in all these matters, where dedicated methods and tools that have been and will be developed can provide policy- and decision-makers with science-based support to shape sustainable societies. It is therefore our hope that some of the key messages highlighted above will be taken up by relevant stakeholders in academia, industry and authorities. We also hope that such a survey can serve as inspiration to others to help identify and prioritise actions to ensure evidence-based, timely and effective implementation of the SDGs.

Acknowledgements

The authors would like to thank the participants of the “Interactive SDG Session” of the 25th CIRP Conference on Life Cycle Engineering held in Copenhagen in 2018 for their valuable contribution. The authors also would like to thank Carlos M. M. Melero for his support in data acquisition.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2019.05.129.

References

Alting, L., Jørgensen, J., 1993. The life cycle concept as a basis for sustainable industrial production. CIRP Ann. - Manuf. Technol. 42 (1), 163–167.
Alting, L., Legarth, J.B., 1995. Life cycle engineering and design. CIRP Ann. - Manuf. Technol. 44 (2), 569–580.
Bjørn, A., Richardson, K., Hauschild, M.Z., 2018. A framework for development and communication of absolute environmental sustainability assessment methods. J. Ind. Ecol. https://doi.org/10.1111/jiec.12820 (in press).
Cosme, N., Hauschild, M.Z., Molin, C., Rosenbaum, R.K., Laurent, A., 2018. Learning-by-doing: experience from 20 years of teaching LCA to future engineers. Int. J.

Life Cycle Assess. 1–13 https://doi.org/10.1007/s11367-018-1457-5.
Fabrycky, W.J., 1987. Design for the life-cycle. Mech. Eng. 109, 72–74.
Fantke, P., Illner, N., 2019. Goods that are good enough: introducing an absolute sustainability perspective for managing chemicals in consumer products. Curr. Opin. Green Sust. Chem. 15, 91–97.
Frydendal, J., Hansen, L.E., Bonou, A., 2018. *Environmental Labels and declarations* (chapter 24, pp. 577-604). In: Hauschild, M.Z., et al. (Eds.), Life Cycle Assessment: Theory and Practice. Springer, Dordrecht, NL, ISBN 978-3-319-56475-3.
Hauschild, M.Z., Herrmann, C., Kara, S., 2017. An integrated framework for life cycle engineering. Procedia CIRP 61, 2–9.
Hauschild, M.Z., Laurent, A., Molin, C., 2018. Advancing life cycle engineering to meet United Nation's sustainable development goals. Procedia CIRP 69, 1–2.
Herrmann, C., Hauschild, M.Z., Gutowski, T., Lifset, R., 2014. Life cycle engineering and sustainable manufacturing. J. Ind. Ecol. 18, 471–477.
ICSU/ISSC, 2015. Review of the Sustainable Development Goals: the Science Perspective. International Council for Science (ICSU), Paris, FR.
Jeswiet, J., 2003. A definition for life cycle engineering. In: Proceedings of the 36th CIRP International Seminar on Manufacturing Systems, 3 June 2003, Saarbrucken Germany, pp. 17–20.
Juraschek, M., Bucherer, M., Schnabel, F., Hoffschröer, H., Vossen, B., Kreuz, F., Thiede, S., Herrmann, C., 2018. Urban factories and their potential contribution to the sustainable development of cities. Procedia CIRP 69, 72–77.
Kara, S., Hauschild, M.Z., Herrmann, C., 2018. Target-driven life cycle engineering: staying within the planetary boundaries. Procedia CIRP 69, 3–10.
Keoleian, G.A., Menerey, D., 1993. Life Cycle Design Guidance Manual: Environmental Requirements and the Product System. US environmental Protection Agency, Washington DC, US. EPA 600/R 92/226.
Keys, L.K., 1990. System life cycle engineering and DF"X". IEEE Trans. Components, Hybrids, Manuf. 13, 83–93.
Kühnen, M., Silva, S., Beckmann, J., Eberle, U., Hahn, R., Hermann, C., Schaltegger, S., Schmid, M., 2019. Contributions to the sustainable development goals in life cycle sustainability assessment: insights from the Handprint research project. Sustain. Manag. Forum 27, 65–82.
Laurent, A., Owsianiak, M., 2017. Potentials and limitations of footprints for gauging environmental sustainability. Curr. Opin. Environ. Sust. 25, 20–27.
Laurent, A., Leclerc, A., Niero, M., Dong, Y., Olsen, S.I., Owsianiak, M., Bey, N., Ryberg, M., Hauschild, M.Z. (Eds.), 2018. The 25th CIRP Conference on Life Cycle Engineering. Procedia CIRP, 69, pp. 1–992. Volume available in Open Access at: https://www.sciencedirect.com/journal/procedia-cirp/vol/69. (Accessed 31 January 2019). Accessed.
Pedersen, C.S., 2018. The UN Sustainable Development Goals (SDGs) are a great gift to business! Procedia CIRP 69, 21–24.
Ryberg, M.W., Owsianiak, M., Clavreul, J., Mueller, C., Sim, S., King, H., Hauschild, M.Z., 2018. How to bring absolute sustainability into decision-making: an industry case study using a Planetary Boundary-based methodology. Sci. Total Environ. 634, 1406–1416.
Schroeder, P., Anggraeni, K., Weber, U., 2019. The relevance of circular economy practices to the sustainable development goals. J. Ind. Ecol. 23, 77–95. https://doi.org/10.1111/jiec.12732.
Secher, A.Q., Collin, C., Linnet, A., 2018. Construction product declarations and sustainable development goals for small and medium construction enterprises. Procedia CIRP 69, 54–58.
Stewart, R., Fantke, P., Bjørn, A., Owsianiak, M., Molin, C., Hauschild, M.Z., Laurent, A., 2018. Life cycle assessment in corporate sustainability reporting: global, regional, sectoral and company-level trends. Bus. Strateg. Environ. 27, 1751–1764.
UN, 2015. Transforming Our World: the 2030 Agenda for Sustainable Development. United Nations Publishing, New York, NY, USA.
van den Bergh, J.C.J.M., 2010. Externality or sustainability economics? Ecol. Econ. 69, 2047–2052.
Vázquez-Rowe, I., Kahhat, R., Larrea-Gallegos, G., Ziegler, K., 2019. Peru's road to climate action: are we on the right path? The role of life cycle methods to improve Peruvian national contributions. Sci. Total Environ. 659, 249–266.
WBCSD, 2010. Vision 2050: the New Agenda for Business. World Business Council for Sustainable Development (WBCSD), Geneva, CH, ISBN 978-3-940388-56-8.
Weidema, B., Goedkoop, M., Mieras, E., 2018. Making the SDGs relevant to business - existing knowledge on the linking of SDGs to business needs and the role of LCA in meeting the needs and filling the gaps. Background of project initiated by UN Environment's Life Cycle Initiative "Linking the UN Sustainable Development Goals to life cycle impact pathway frameworks". Webpage: https://www.lifecycleinitiative.org/new-project-linking-the-un-sustainable-development-goals-to-life-cycle-impact-pathway-frameworks/. (Accessed 30 April 2019). Accessed.
Wulf, C., Werker, J., Zapp, P., Schreiber, A., Schlör, H., Kuckshinrichs, W., 2018. Sustainable development goals as a guideline for indicator selection in Life Cycle Sustainability Assessment. Procedia CIRP 69, 54–58.