Int J Life Cycle Assess (2017) 22:1477–1481
DOI 10.1007/s11367-017-1320-0

CONFERENCE REPORT

Towards a research agenda for the use of LCA in the impact assessment of policies

Francesca Reale[1] · **Marco Cinelli**[2] · **Serenella Sala**[1]

Received: 24 February 2017 / Accepted: 3 April 2017 / Published online: 20 April 2017

1 Introduction

Life cycle thinking and life cycle assessment are vital elements of sustainability assessment and increasingly mentioned as being essential for informing decisions in a comprehensive and holistic manner in both business and policy contexts (Sala et al. 2013). The European Commission has recently released a Communication on Better regulation (CEC 2015a) in order to improve the policy making process. The Communication is complemented with a Better Regulation toolbox (CEC 2015b) which lists models and methods to be used for assessing impacts and benefits of policies, in the so called "policy impact assessment" step. Life cycle assessment is listed among the models, aiming at supporting the environmental assessment of impact and benefits associated to different policy options (Sala et al. 2016).

Life cycle assessment (LCA) may play a relevant role all along the policy cycle, from policy anticipation and problem definition, to policy evaluation. Indeed, the life cycle perspective and the systemic approach to the evaluation of options is a crucial added value. However, when the scope of the assessment changes from the product (micro) scale to the system (meso-macro) scale, several improvements are required to benefit the most from the LCA methodology. Suitable frameworks, methods, and tools for system analysis are needed to properly develop sustainable policies on, e.g., bioeconomy, circular economy, resources efficiency, eco-innovation and sustainable production, and consumption. This calls for reflecting upon current and future challenges of the application of LCA within the policy development cycle.

The Joint Research Centre of the European Commission organized a workshop on the 13th and 14th of December 2016 aimed at discussing the role of LCA in the policy cycle with particular reference to the impact assessment (IA) step. The IA is the integrated process to assess and to compare the merits of a range of policy options designed to address a well-defined problem (CEC 2015a) and represents a well-established step in the European policy development.

The workshop gathered relevant experts in the area of application of LCA to policy within and beyond the European Commission services. Overall, 37 experts participated in the workshop both from the EU institutions and from leading research centers and universities. The main objective was to identify relevant points for a research agenda for the use of LCA in IA, answering to crucial questions such as: Which methodological developments are needed to address the complexity of policy evaluation in LCA? How can scenario modeling and foresight studies further inform the LCA? How can LCA results be better presented in order to improve their interpretation and comprehensiveness to finally support policies?

The IA of policy addresses the three pillars of sustainability, economic, social, and environmental. Some key features of LCA are particularly relevant for addressing sustainability problems, in particular: the life cycle perspective, the identification of the most important burdens and most relevant life cycle stages contributing to environmental and social impacts, the identification of environmental (and

Responsible editor: Mary Ann Curran

✉ Serenella Sala
serenella.sala@ec.europa.eu

[1] European Commission - Joint Research Centre, Directorate D: Sustainable Resources, Bioeconomy Unit, Via Enrico Fermi 2749, Ispra, VA, Italy

[2] Institute of Advanced Study & WMG, University of Warwick, Coventry, UK

social) "hot spots" of goods/services/systems/technologies/innovations/infrastructures, and the identification of unintended burdens shifting between environmental (social) impacts (reducing one impact while increasing another) and over life cycle stages.

In the context of the challenges posed by environmental sustainability assessment, LCA plays a key role as it can provide support to policy-makers towards more transparent and evidence-based decisions, as requested by the Better Regulation. A broad and international discussion on the need of a guidance for the application of LCA in the policy is ongoing. Several elements may affect the results and policy support, including data quality, modeling approach, methodological choices, and uncertainty analysis. Further guidance tailoring LCA for policy needs are of upmost importance.

The aim of this conference report is to provide a short summary of topics presented and discussed during the workshop. The workshop was structured in different sessions presented in Section 2, whereas Section 3 provides the conclusions and the way forward for the research agenda.

2 Main workshop topics

The workshop was organized to cover four main points of discussion: the actual and future role of LCA in the policy cycle (Section 2.1), the lessons learnt from the application of LCA to the "policy impact assessment" (Section 2.2), the methodological challenges in the application of LCA to policies (Section 2.3), and the key issues in the interpretation and communication of results (Section 2.4).

2.1 LCA within the policy cycle: past, present, and future

The Better Regulation package was presented in relationship to its driving principles related to the policy development process and the enhancement of stakeholders' involvement. A particular focus was placed on the policy IA step, illustrating the new Regulatory Scrutiny Board, its composition and IA process, and the need for regularly updating the toolbox with improved and/or new methodologies for supporting the assessment of policy options (Michał Narozny, European Commission, Secretariat General).

An overview of occurrence of LCA in policies has been presented (Serenella Sala, European Commission, JRC) including a proposal on the potential role of LCA at each step of the policy cycle. In fact, LCT and LCA have been integrated in several EU environmental policies over the last two decades. These include both legislative acts, such as regulations or directives, as well as decisions, communications, and recommendations.

A recent case study of application in the context of Italy was also illustrated (Paolo Masoni, ENEA), stemming from the Italian Law 221/2015[1] establishing the national voluntary schemes for products "Made for green in Italy," fully based on the LCA methodology and compliant with the European Commission Environmental Footprint (CEC 2013a, 2013b). This is the first application, in an EU Member State, of the European Product Environmental Footprint methodology.

In the context of supporting environmental policy development and evaluation, the European Environment Agency (EEA) (Ybele Hoogeveen) has illustrated the role of the EEA and the need of integrating more LCA results in the process informing policy making. The flagship assessment produced by EEA is 'The European environment – State and outlook' (SOER), published every 5 years. According to the SOER2015 (EEA, European Environmental Agency 2015), policies have delivered substantial benefits for the environment, economy, and people's well-being, but major challenges remain, linked to production and consumption systems and the rapidly changing global context. For the transition towards the 2050 vision, as defined by the 7th Environmental Action Programme (EAP) (CEC 2013c), more ambitious actions are required on policy, knowledge, investments, and innovation levels. Key challenges identified where related to the need of ensuring consistency between different scales (e.g., between products and systems) and enhancing system- and holistic-thinking.

2.2 Lesson learnt from the application of LCA in the impact assessment of policies

Some lessons can already be learnt from the past, such as from the case study of LCA's use supporting bioenergy evaluation (SWD (2016)418). Namely, when the goal of the impact assessment is to assess the consequences of a policy, then impacts caused by various policy choices against one (or multiple) baselines (e.g. biomass alternative uses to bioenergy) should be investigated through consequential LCA.

A case study of IA in the field of biofuel transportation was presented (SWD (2016)418) as an example of contribution of LCA to inform policy evaluation. It was pointed out that simplified methodologies such as GHG saving metric and attributional LCA (A-LCA) are not able to properly capture the complex interaction of bioenergy with the climate system and can only be used to benchmark different pathways on a common scale (Luisa Marelli, European Commission, JRC). Methodological developments presented in the last years include the introduction of consequential thinking into attributional analysis which can enable a better accounting and assessment of the climate change mitigation potential of

[1] http://www.gazzettaufficiale.it/eli/id/2016/1/18/16G00006/sg.

bioenergy systems. Results are considered more comprehensive and robust compared to a traditional A-LCA. They provide an indication of potential risk rather than "single-number" results. In general, more complex tools are needed to consider and assess market-mediated effects, biophysical phenomena, and climate responses; and LCA practitioners should interact more actively with other modelers, including experts in uncertainty management and modeling (Jacopo Giuntoli, European Commission, JRC).

The second case study was in the area of fertilizers (Hans Saveyn, European Commission, JRC), in the frame of EU efforts to recognize organic and waste-based fertilizers in the single market and support the role of bio-nutrients (EC, European Commission 2015). With respect to this, a proposal for a revision of the Fertilizers Regulation EC 2003/2003 (EC, European Commission 2016) was adopted and, in this context, product and process criteria are being developed for emerging fertilizers such as struvite, biochar, and ash-based materials to allow these entering the single market with full CE product status. The use of life cycle elements is planned to "ensure that further efforts in promoting recycling of waste based materials, by developing criteria for new products, do not result in local or overall adverse environmental and human health impacts". These life cycle elements will be complemented with an assessment of the diverse socio-economic aspects related to the possible introduction of such renewable fertilizers on the market.

2.3 Methodological challenges in the application of LCA to policies

Modeling aspects are a crucial component of any LCA and are of utmost relevance when discussing the application of LCA for policy IA. In policy making support, a comparative assessment of future scenarios with and without policy option implementation is performed. For example, regarding the use of A-LCA or C-LCA, the latter seems straightforward as far as the boundaries of the study can include activities and sectors not directly related to the policy under scrutiny, and the foreground inventory model is resulting from economic and/or behavioral drivers which are not explicitly considered in attributional LCA (Enrico Benetto, LIST). The use of partial/computable general equilibrium models (economy driven) and/or agent based modeling (behavioral rules driven) has been mentioned as main challenge in relationship to the modeling of the foreground LCI system. The relevance of the early involvement of policy makers in the modeling was stressed. Benetto presented three case studies on energy, mobility, and agriculture developed in Luxembourg, highlighting the higher computational efforts needed as compared to A-LCA and C-LCA based in simplified market modeling (Weidema et al. 2009).

The need of properly addressing uncertainties all along the LCA phases, from inventory to final results, was also discussed. It was pointed out that complexity, uncertainty, and variability of the systems are not sufficiently addressed by traditional LCA, usually providing "exact" values of impacts that can be misleading when presented to decision makers. An example on vehicles was presented. It was pointed out that uncertainties are an inherent part of any LCA study and shall not be avoided but quantified and made explicit in the result (Maarten Messagie, Mobi-ETEC).

At the same time, policy needs clear guidance. Another key topic is the allocation issue, whose pros and cons have been illustrated (Reinout Heijungs, CML, Leiden). The mainstream solutions of the allocation problem, as suggested by ISO and ILCD (ISO, International Organization for Standardization 2006a, 2006b; EC-JRC 2010), have all weak and strong points, so none of them should be preferred, in principle.

Moreover, process-based LCA are usually complemented or contrasted by the use of Extended Environmental Input/Output (EEIO) approaches. Hence, the potential use and role of I/O and of hybrid LCA approaches for supporting policies were presented (Jannick Schmidt, University of Aalborg). This included an introduction to the multi-regional hybrid input-output database Exiobase v3 as well as a general definition of what is meant by "hybrid LCA approaches." The role of hybrid LCA was highlighted for different stages of the policy-making process, including hotspot analysis, improvement analysis, detailed impact assessment of policy options/instruments by implementing scenarios in the model, and monitoring the development of environmental indicators and effects of policies.

In relation to environmental impact assessment, several aspects are currently under discussion and development. Two issues are of particular relevance for supporting policies: the modeling of ecosystem services and biodiversity where common understanding and harmonization has still to be fostered. The presentation by Benedetto Rugani (LIST) highlighted the need for determining consensus on how to assess ES and biodiversity in LCA. This included the need of developing new schemes for impact assessment of ES in LCA, for example, based on Payments for Ecosystem Services (PES) (Smith et al. 2013; Wunder 2015) models, which could feed into the "Better Regulation «Toolbox»" and complement more traditional cost-benefit analysis.

Besides, scenario modeling was discussed, presenting a case study on Eco-industries (Vera Calenbuhr, European Commission, JRC). This offered the occasion to discuss on the extent to which environmental policies shape technology as well as the road towards a cleaner, possibly more sustainable future. The question as to whether environmental policy driven by evidence-related resource use and

environmental impacts (i.e., a detailed LCA-framework) could possibly be simpler, more effective, and more efficient than contemporary environmental policy has been discussed as well.

2.4 Interpretation and communication of results

A specific session focused on key elements for decision support when multiple indicators are to be presented, as in LCA, in particular when a need of weighting and aggregation is emerging. A debate is ongoing, internationally, to provide guidance to LCA practitioners on the use of normalization and weighting for interpreting LCA results (Pizzol et al. 2016).

Several weighting methods exist to weight impact categories in LCA, such as (i) distance-to-target, (ii) panel-based, (iii) monetary valuation, (iv) mid-to-endpoint, and (v) meta-models. The presentation by Marco Cinelli (University of Warwick) provided an overview of the methods. Moreover, he illustrated a proposal, developed at the European Commission–JRC, for deriving a weighting set, based on a hierarchical structure exploiting the budget allocation technique to be used within the Environmental Footprint (EF) (CEC 2013a, 2013b). The development of weighting sets building on the experience gained in the Multi Criteria Decision Aiding (MCDA) domain and fostering a communication between the scientific and the social domain is a key element for improving LCA-based decision making.

MCDA (Tsoukiàs 2007; Roy 2016) is a suitable candidate as it provides a structured decision support framework that can be used to weight and integrate the LCA data (from midpoints and endpoints) in the form of easily understandable rankings, performance scores, and classifications of the policies under evaluation (Luis Dias, FEUC, University of Coimbra). A clear distinction was presented between the MCDA methods that provide absolute and relative recommendations from the integration of the LCA results. In the first case, the outcomes of the MCDA evaluations (e.g., ranking, scoring) are independent from the other alternatives whereas in the latter case, they depend on them (policies included) since the assessment is performed on a pair-wise comparison basis (e.g., most outranking methods) or the assessment is performed relatively to the best and worst values among the set of alternatives (e.g., the TOPSIS method).

Challenges in applying MCDA to aggregate impact assessment indicators were discussed too. A main aspect is the need of accounting for the difference between weights as trade-offs and importance coefficients according to the aggregation algorithm. MCDA usually compares multiple alternatives, which is not the case in many LCA studies. A typical MCDA elicits preferences from a decision maker, but it is often the case in LCA that there is no well-identified one (Luis Dias).

3 Conclusions

The workshop provided the opportunity to discuss the most relevant aspects related to the use of LCA for the IA of policies, thus highlighting the need to improve several aspects of the methodology, especially when the study is intended to support as well an integrated assessment including economic and/or social issues. The discussion was centered on the identification of points for a research agenda for the use of LCA in IA of policies, which will be further developed and presented in a joint discussion paper.

Acknowledgements We would like to thank Enrico Benetto (Luxembourg Institute of Science and Technology, Luxembourg) for co-organizing the workshop, as well as the speakers and all the participants for their valuable contributions to the discussion. The work of Marco Cinelli was supported by the Institute of Advanced Study from the University of Warwick under the Early Career Fellowship scheme in award number IAS/ECF/250452/15 and the Innovative Manufacturing Global Research Priority at the University of Warwick (UK).

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