Chapter 2
The Role of the Society of Environmental Toxicology and Chemistry (SETAC) in Life Cycle Assessment (LCA) Development and Application

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Abstract Although there was a demand for environmental health data on chemicals, there was no global scientific organization able to talk about the science behind the regulations being developed. The Society of Environmental Toxicology and Chemistry (SETAC) was founded in 1979. SETAC has three strengths: its global scale, its tripartite membership and governance, and its scientific base. Because SETAC was developed on an international scale, it has been able to address global environmental issues.

The SETAC North American LCA Advisory Group is a formally recognized group within SETAC that has been in existence since June 1991. Similarly, SETAC Europe established an LCA Steering Committee. Both the LCA Advisory and Steering Committee are referred to as the SETAC LCA Groups.

The LCA Groups report to the Board of Directors of both SETAC and SETAC Europe. Specific activities such as workshops, conferences, or educational material development, including 'position papers', are approved by the Board of Directors. During the 1990s these SETAC LCA Groups were instrumental in driving the scientific progress to codify the professional practice of LCA. During this time period, several major workshops were successfully organized and over a dozen key publications produced. The SETAC LCA Groups also broadly supported the initial preparation of the ISO 14040 series of voluntary international standards as well as their subsequent revisions.

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The general mission of the SETAC LCA Groups is to proactively advance the science and application of LCAs to reduce the resource consumption and environmental burdens associated with products, packaging, processes or activities.

Although life cycle assessment promised to be a valuable tool in evaluating the environmental consequences of a product, process, or activity, the concept was relatively new and required a framework for further development.

The workshop, 'A Technical Framework for Life Cycle Assessments', held August 18–23, 1990, at Smugglers Notch, Vermont, was organized by SETAC to develop a framework and consensus on the current state of LCA and research needs for conducting life cycle assessments. Although life cycle assessments have been used, in one form or another, before the name was coined, this workshop report is the first document which presented the name of the method.

The four SETAC LCA workshops in Smugglers Notch (1990), Leiden (1991), Sandestin (1992) and Wintergreen (1992) formed a tiered process to culminate in the Code of Practice workshop of Sesimbra, Portugal, March 31–April 3, 1993.

Developing international consensus on harmonized methods has been a goal of the SETAC LCA workshops. The 'Code of Practice' completed the harmonization process. Shortly after the workshop, during the autumn of 1993, the ISO standardization process was initiated.

In 1994, as a result of the SETAC LCA workshops, the LCA Advisory Group of SETAC and the LCA Steering Committee of SETAC Europe established individual work groups to address specific LCA issues.

SETAC's working groups and workshops have advanced both the application and reputation of Life Cycle Assessment (LCA) by authoring LCA publications, supporting the development of LCA standardization, partnering with United Nations Environmental Programme (UNEP), and advancing the use of LCA in various sectors. As SETAC grows and expands on its own and with its supporters and partners, it will continue to advance the understanding and use of LCA while ensuring that science is kept at the forefront of LCA development.

Keywords Global coordinating group (GCG) • International organization for standardization (ISO) • LCA in developing countries • LCA in the building sector • Life cycle assessment (LCA) • Pellston workshops • SETAC Europe LCA steering committee • SETAC LCA groups • SETAC North American LCA advisory group • UNEP/SETAC Life cycle initiative • Work groups life cycle impact assessment •Work groups simplified/Streamlined LCA • Workshop Leiden • Workshop Sandestin • Workshop Sesimbra • Workshop Smugglers Notch • Workshop Wintergreen

1 Introduction—SETAC and Life Cycle Assessment

Google labs' Books Ngram Viewer allows any user to graph the frequency of occurrence of words or phrases in Google's database of 500 billion words from digitized books. That technology enticed the senior author to investigate the relationships of

a number of Life Cycle Assessment (LCA)-related words over time. One combination, 'SETAC' (Society of Environmental Toxicology and Chemistry) and 'life cycle assessment,' yielded a very interesting observation for the years 1980–2008.

The 'SETAC' acronym first appeared in books in the 1980s. The frequency of appearance grew steadily from 1990 through 2004, showing a tenfold increase. In 1990, SETAC sponsored an international workshop where the term 'life cycle assessment' was coined. SETAC subsequently established the accepted name (and framework) for life cycle assessment (Fava et al. 1991). Previously, a few practitioners in the United States and Europe used different terms such as 'Resource and Environmental Profile Analysis' (REPA) (Hunt and Franklin 1996).

The occurrence of the phrase 'life cycle assessment' in books grew very similarly to the occurrence of 'SETAC' from 1990 through 2004. Was this a coincidence or were there activities within SETAC that contributed to this parallel growth? As growing interest in green buildings and sustainable products (to name a few drivers) increased the use of LCA, a review of the recent history behind SETAC's role was required. Klöpffer (2006) provides an excellent summary of the role of SETAC in the development of LCA; and Ekvall (2005) outlines the further advancement of LCA by SETAC's LCA working groups.

2 Life Before SETAC's Involvement with LCA

2.1 Focus on Pollution Reduction

In 1969, the Cuyahoga River in the United States became infamous for being 'the river that caught fire'. This event helped spur the environmental movement. The river burned because of pollution dumped in it by nearby industrial and waste water operations. At the time, there were few environmental laws providing direction or restriction of environmental releases for companies. The river that caught fire became a national symbol of the fundamental flaws in the way society treated the environment.

Laws and regulations were instituted in the early 1970s that placed new and/or additional controls on point-source releases of waste from treatment facilities and industrial operations. As a result, the water quality of the rivers improved. There is still much to learn about the risks of ingredients and emissions from our products and processes that enter our rivers and waterways, but significant progress has been made.

These governmental and regulatory expectations, placed on companies and government behavior, primarily related to the management of emissions and waste from manufacturing operations (and later the cleanup of abandoned or contaminated land). They were instrumental in creating a change for improved environmental management.

In the 1980s, many regulatory approaches to environmental protection continued to be based on 'end-of-pipe' solutions that focused on a single medium (e.g., air, water, or soil), a single stage in the product's life cycle (e.g., production, use, or disposal), or a single issue (e.g., individual chemical limits). Such strategies did not always lead to a net environmental benefit. Environmental laws and regulations that have a single focus often force the use of pollution control resources in ways that are not optimal for reducing overall impacts.

The attempt was made to solve a single environmental problem without considering the interconnectivity of natural systems. Designed legislation, although intended for a specific purpose, has regularly created additional, unexpected environmental problems. Single-issue approaches are often not designed with a systematic understanding of the tradeoffs and their implications. Thus, they frequently diminish opportunities for achieving net environmental improvements.

One of the rapidly evolving landscapes in business today is adaptability to the changing nature of environmental impact management. This occurs as scope expands from a single site and/or issue to a full understanding of the impacts of our products over their entire life cycles. Many advertisements pitch 'green' product traits, but all products have environmental impacts. Materials and crude oil are extracted from the earth, processed, combined with other materials to make parts, assembled into finished products, shipped to customers, and ultimately delivered to final consumers who use the products and dispose of them. Along that value chain, energy is used, waste is generated, and more natural resources are consumed. Sustainability will require us to continue creating value for society while reducing environmental and social impacts.

2.2 Moving Beyond Pollution Control to Pollution Prevention

With the improvement in the treatment of air and water emissions and waste from manufacturing operations, there was recognition that end of pipe treatment can only go so far. Additional examination of what enters the end-of-pipe treatment was needed. This led to the development of pollution prevention and pre-treatment programs. These programs were not as influenced by explicit government regulations. It did become clear, at least in some groups, that preventing pollution from entering the environment could save the organization money and protect the environment. 3M's Pollution Prevention Pays (3P)program, was a landmark program initiated in the 1980s which has saved 3M 1.2 billion dollars worldwide. As well, it has prevented 2.9 billion pounds of pollutants from entering the environment.

In the 1970s and 1980s, there were a number of studies and situations that created the demand for additional information on environmental impacts of products. These were primarily driven by solid waste management issues. Three in particular are relevant to this conversation[1]: (1) duelling diaper debates; (2) mercury in fluorescent light bulbs; and (3) Coco-Cola demanding supply chain improvements.

[1] These were presented in Fava (2012) Life cycle knowledge informs greener products, Chap. 25, in: Curran MA (ed) LCA Handbook—a guide for environmentally sustainable products.

2.2.1 Duelling Diaper Debates

Many of us remember the garbage barge that went up and down the east coast of the United States in the late 1980s looking for a disposal site. In this period, there were concerns about the significant amount of solid waste that society was generating. Today that concern remains, but society has realized that there is a broad and growing array of environmental issues. A study by the cloth diaper industry revealed that the use of cloth diapers did not create as much solid waste as the use of disposable diapers (now called single-use diapers). Subsequently, there was a push to use more cloth diapers and reduce the number of single-use diapers sent to landfills. However, additional studies, using methods including life cycle assessment, showed that cloth diapers also have meaningful environmental impacts during use (e.g., heating water for washing). It became unclear which product was actually better. The 'Dueling Diaper' LCA studies raised awareness of the diversity of environmental impacts that products can create and the environmental trade-offs between product options.

What did we learn? One of the most significant lessons was the realization that, depending upon the impact in question and where it occurs, different and equally valid interpretations can result. These early studies revealed that all products have impacts on the environment. LCA tools enable decision makers to use new and additional information on multiple metrics to make better-informed decisions. A clear recognition of the importance of continuing to ensure performance of the product is maintained and improved.

2.2.2 Mercury in Fluorescent Light Bulbs

Society and policy makers were faced with demand to reduce mercury levels associated with lighting systems in order to reduce the overall release of mercury into the environment. While incandescent bulbs contain no mercury, mercury is a critical element in fluorescent bulbs that increases efficiency and durability. The resulting reduction in energy consumption causes a corresponding drop in mercury emissions from coal-fired power plants. Due to the concern about mercury entering the environment from landfills, policy makers were wrestling with two options: banning fluorescent lamps from municipal solid waste (MSW) facilities or encouraging greater use of fluorescent lamps over incandescent lamps. If we only consider the amount of mercury that might enter the environment as a result of bulb disposal, it is clear that significantly more mercury would come from florescent bulbs because incandescent bulbs don't contain any mercury.

However, if we expand the system boundaries to include the use phase of the bulbs in addition to their disposal, what does the data reveal? Surprisingly, we find that the use and disposal of incandescent lights released into the environment, on average, *four to ten times as much mercury* as the use and disposal of fluorescent lights. This is due to the additional power plant emissions created by the inefficient incandescent bulbs during the use phase. The US Environmental Protection Agency

(EPA) estimated, in the early 1990s, that the use of fluorescent lights will also eliminate the following:

- 50 % of aggregate national electricity demand;
- 232 Million t of CO_2 emissions each year;
- 1.7 Million t of SO_2 emissions each year; and
- 0.9 Million t of NO_2 emissions each year.

Clearly, when the system boundaries and the impacts of interest are expanded to include bulb use as well as disposal, the better decision is to encourage greater use of fluorescent bulbs. This was, in fact, the direction taken by policy makers: *use fluorescent bulbs* but challenge lighting companies to *reduce the mercury in those bulbs*. This policy enabled reduction of mercury releases and encouraged innovation to develop lighting systems containing less mercury. Philips' Sustainable Lighting Solutions and its ALTO® bulbs[2] are good examples of environmentally responsible lighting because they contain less mercury, are Toxicity Characteristic Leaching Procedure (TCLP[3]) compliant, energy efficient and last longer. Responsible lighting solutions result in fewer light bulbs in landfills and further reduce the impact on the environment.

What did we learn? By taking a broader systems approach, we can make better decisions. Using this systems thinking, the lighting sector has produced innovations over the years to develop better products with lower environmental impacts.

2.2.3 Coca-Cola's Supply Chain Improvements

In the early 1970s, the Coca-Cola Company conducted a study of its beverage containers. The results showed that all of their beverage containers had real environmental impact. In response, Coca-Cola decided to challenge the material and container companies to make adjustments to their products and processes that would result in reduced life cycle environmental impacts over previous design options. This was contrary to common practice at the time to simply ban or deselect the poorest-performing material(s)[4]. For Coca-Cola's aluminum cans, the sector worked with local governments to develop a recycling infrastructure for the used beverage containers, resulting in a reduction of more than 90 % in the energy used throughout the life cycle of the aluminum beverage container. Other material groups made similar improvements in a response to Coco-Cola's challenge.

What did we learn? LCA study results should be used to improve product environmental performance. As Coca-Cola chose not to ban any of the high environmental

[2] http://www.usa.philips.com/c/fluorescent-tubes/296298/cat/en/.

[3] The Toxicity Characteristic Leaching Procedure (TCLP) is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes. http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/1311.pdf.

[4] Information based on personal conversations with Coca-Cola employees.

burden materials, they created an atmosphere that allowed for material innovation such as the development and financing of a recycling infrastructure to recapture the inherent value in the aluminum.

3 The Birth of SETAC

Rachel Carson's 'Silent Spring'[5] was published in 1962 and the world was awakened to the implications of wide spread chemical and pesticide use on the environment. Federal laws around the world were passed that began to demand additional information on the fate and effects of chemical use on the environment. This information was to inform the determination related to what might be acceptable and safe use and application rates for chemicals and pesticides used in commerce. However, this created a need for internationally acceptable methodologies and risk assessment frameworks. These frameworks could be applied and used to examine and evaluate the safe and acceptable levels of chemical use. Although there was a demand for environmental health data on chemicals, there was no global scientific organization able to talk about the science behind the regulations being developed.

In 1979, The Society of Environmental Toxicology and Chemistry (SETAC) was founded to serve as a non-profit professional society to promote the use of multidisciplinary approaches in the study of environmental issues. SETAC has three unique strengths: its global scale, its tripartite[6] membership and governance and its scientific base. Because SETAC was developed on an international scale, it has been able to address global environmental issues. In October 1980, there were 230 Charter Members. Today, there are nearly 6,000 members from more than 100 countries. SETAC's members, from governmental, academic, and business backgrounds, are committed to balancing the scientific interests of the three sectors represented.

3.1 SETAC Workshops

From the beginning, SETAC has sponsored workshops to bring together scientists, engineers, and managers from government, private business, academia, and public interest groups to consider the state-of-the-art of specific environmental topics. While formats vary, workshops are generally held over the course of 4–5 days with 40–50 individuals in attendance. During the intensive workshops, a combination of formal presentations and informal working sessions are used to examine the status of current information and the knowledge base of the topic and develop recom-

[5] Carson (2002) [1st Pub. Houghton Mifflin 1962]. Silent Spring. Mariner Books.*ISBN 0-618-24906-0*. Silent Spring initially appeared serialized in three parts in the June 16, June 23, and June 30, 1962 issues of *The New Yorker* magazine.

[6] SETAC has a commitment to balance the scientific interests of government, academia and business.

mendations for enhancing the current state of the science. An expected product of a SETAC workshop is a document that presents a clear description of this knowledge and a description of the recommendations developed.

There are two general categories of SETAC Workshops: Pellston Workshops, named after the location of the first workshops (University of Michigan Field Station, Pellston, MI, USA) and Technical Workshops, including Small Meetings. The distinction between these two categories is primarily a function of the anticipated breadth of interest in the topic across the SETAC membership, the criticality and timeliness of the topic, and the likelihood that the workshop will significantly advance scientific understanding of the issue. The basics of balance and objectivity underlying all SETAC activities apply to all SETAC workshops. This foundation has been the key to the successful workshops for the past 30 years on topics ranging from LCA to improving management of contaminated sediments.

All SETAC workshops must adhere to the following fundamental guidance principles:

- Proposed workshop is consistent with SETAC goals;
- Proposed content is scientifically sound or credible;
- Workshop promotes multi-disciplinary approaches;
- Workshop attendance ensures balance in opinion and representation by involving relevant constituencies (from academia, government, business and non-governmental organizations);
- Workshop has a viable communication plan coordinated with the SETAC Publications Advisory Council (PAC) and the Public Relations and Communication Committee (PRCC) that ensures timely, accurate and cost-effective publication of results to the Society and sponsors as well as to a wider global audience. Web-based communications, such as webinars, podcasts, or blogs, are also encouraged to the extent they increase the base of knowledge of the workshop findings and complement other, more traditional means;
- Proposed workshop does not generate a conflict of interest; and,
- Workshop budget is viable, including publication costs, and financial liability to SETAC is controlled.

3.1.1 Pellston Workshops

The goal of a Pellston Workshop is to promote advancement in the resolution of truly cutting-edge technical and policy issues in environmental science, while enhancing strategies of science and philosophy.

Developing the Workshop Topic Workshop proponents, at least one of whom must be a SETAC member or an individual SETAC member, will identify a pertinent issue or environmental topic to serve as a focal point for the proposed workshop and form a tentative Workshop Steering Committee which includes at least one SETAC Office staff member as an ad-hoc member. The tentative Steering

Committee or individual will develop a pre-proposal (concept paper) that clearly describes the topic to be examined, the workshop objectives, the anticipated range of participants, any potential funding sources, and the benefits to be obtained from the workshop. The SETAC Office should be contacted for example documents, for advice on preliminary workshop organization, for ideas on tentative dates and location, and for funding requirements for the workshop and follow-up activities. If the Board/Council feel that the pre-proposal for the workshop is worthy, it will approve preparation of a complete proposal. This proposal is submitted to the Technical Committee, through the SETAC Office, for technical review.

Technical Committee Review After referral from the Board of Directors/Council, the appropriate national SETAC Technical Committee would review the proposal in reference to the *Criteria for Designation of SETAC Pellston Workshops* and *Criteria for Designation of SETAC Technical Workshops.* Based upon this review, the Technical Committee would provide a recommendation to the Board of Directors/Council on the degree to which the workshop should be sponsored[7].

Based on the recommendation of the relevant Technical Committee and in light of other demands on the SETAC Office and the probability of obtaining adequate funding for the proposed workshop, the Board, Council, or SETAC World Council (SWC)[8] would approve or disapprove the workshop/meeting or the SWC would refer back to national level as a technical workshop as relevant. This would take place at any regularly scheduled meeting throughout the year or by ballot.

Planning the Workshop After approval by the SETAC Board of Directors, workshop proponents may initiate the planning process, cooperatively with the SETAC/SETAC Foundation Office.

Types of Publications From Workshop Proceedings Publication and dissemination of proceedings from workshops is highly encouraged. The outline and format for the publication is dependent upon the workshop objectives and program. Development of a complete first draft of the proceedings during the workshop is essential. After the workshop is held, it is the responsibility of the Workshop Steering Committee to ensure that the proceedings are completed.

Success of Pellston Workshop While SETAC was founded to promote the use of multi-disciplinary approaches for the study of environmental issues, the format of the Pellston Workshop laid the foundation necessary to address life cycle assessment (LCA).

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[7] The following recommendations are possible: Recommend SETAC sponsorship as a Pellston Workshop and submission to the SWC Technical Committee for consideration; Recommend SETAC sponsorship as a Technical Workshop at a national level; Recommend SETAC sponsorship as a Small Meeting at national level; Recommend SETAC sponsorship contingent upon securing funding; Recommend SETAC sponsorship contingent upon incorporation of mandatory changes; Recommend SETAC sponsorship with minor changes suggested; or, Recommend against SETAC sponsorship.

[8] The SWC facilitates worldwide outreach to environmental scientists, engineers, and managers and encourages development of additional SETAC member groups.

3.1.2 Technical Workshops

SETAC supports the convening of technical workshops to bring together experts to discuss and resolve timely technical, scientific or policy issues related to environmental science. SETAC's level of support can range from simply providing an endorsement (e.g., non-exclusive license to use SETAC name or logo for promotional purposes) to providing full technical and scientific support, as long as basic principles are met. Recognizing the diversity of possible workshop formats and varying levels of potential logistic and financial involvement, SETAC's approval and sponsorship criteria are generally flexible and determined primarily by the level of support sought by the applicant. The governing principle: the greater support that is requested from SETAC (in terms of support and financial commitment), the more detail and oversight will be required from the applicant.

Among the flexible workshop formats, there are three general levels of SETAC involvement:

- *Level 1—SETAC-hosted technical workshop or meeting:* Major workshop, hosted by SETAC, of global, regional or national relevance on an important, but not necessarily urgent environmental scientific or policy issue (i.e. non-Pellston), organized and advertised by a SETAC-assembled Steering Committee, with all-invited attendance, significant scientific input, major SETAC financial and logistical support and a substantive high-quality publication.
- *Level 2—SETAC-co-organized technical workshop:* Workshop of global, regional or national relevance, co-organized by SETAC (in partnership with other organizers), with significant scientific input, some SETAC financial and logistical support, but limited financial liability and less comprehensive publication effort.
- *Level 3—SETAC sponsored technical workshop or meeting:* Workshop is organized by a different organization, but endorsed, co-sponsored or advertised by SETAC, with a certain degree of scientific input, but minor or no financial and logistical support.

The goal of a SETAC-hosted or co-organized technical workshop (Level 1 or 2) is to promote advancement of the resolution of important technical and policy issues in environmental science while enhancing strategies of science and philosophy.

To that end, the following criteria have been developed as guidance for the designation of SETAC Technical workshops (in addition to the general guidance principles listed above):

- The proposed workshop topic does not merit a Pellston workshop designation;
- Potential sources and estimated amounts of funding are clearly identified;
- SETAC member participation in balanced Steering/Organizing Committee is required;
- Steering Committee Chair or Co-Chair is a strong champion for the proposed workshop. Members of the steering committee must include recognized subject matter experts germane to the workshop topic;

- Steering Committee and workshop participants must represent an internationally or nationally diverse group of individuals representing academia, government, business, and other non-government organizations;
- Workshop topic is recognized as being an important, although not necessarily pressing, scientific issue by the Science/Technical Committee and Council/Board of the host SETAC unit, and is expected to be of significant interest to a reasonable number of people in the environmental community;
- Workshop objectives are clearly identified and the workshop is designed so that important aspects of the topic can be addressed and definitive conclusions/action items can be developed within the time frame of the workshop;
- Proposed workshop products have a high likelihood of contributing to our understanding of an important issue in environmental science and will be recognized as being of value to specific sectors within the scientific community (i.e., establishing what is known, where uncertainties exist, what research is needed to address those uncertainties);
- An adequate publications and communications plan has been formulated that includes at a minimum an Executive Summary document, a SETAC Globe article and a Presentation at an annual SETAC meeting. In addition, weblog report, webinar or podcast is strongly recommended to further disseminate outcomes; and,
- The potential for conflict of interest does not exist or is acceptably resolved.

4 Early Days of SETAC 1990–1993

4.1 SETAC LCA Groups

The SETAC North American LCA Advisory Group is a formally recognized group within SETAC that has been in existence since June 1991. Similarly, SETAC Europe established an LCA Steering Committee. Both the LCA Advisory and Steering Committee are referred to as the SETAC LCA Groups. The following provides an overview of the initial organization and roles of the SETAC LCA Groups[9].

The LCA Groups report to the Board of Directors of both SETAC and SETAC Europe. Specific activities such as workshops, conferences, or educational material development, including 'position papers', are approved by the Board of Directors. During the 1990s these SETAC LCA Groups were instrumental in driving the scientific progress to codify the professional practice of LCA. During this time period, several major workshops were successfully organized and over a dozen key publications produced. The SETAC LCA Groups also broadly supported the initial

[9] Although the specific details between the two SETAC LCA groups may be slightly different, the intent of this section is to describe the role and value of the SETAC LCA groups in advancing LCA within SETAC generally.

preparation of the ISO 14040 series of voluntary international standards as well as their subsequent revisions (see Sect. 5 for more information).

SETAC LCA Group Organization and Structure SETAC guidelines call for an LCA Group to organize itself around a basic structure consisting of a leadership group, rank and file members. The leadership consists of elected LCA Groups between 6 and 15 members, each. The LCA Group composition should reflect the tripartite (business, academia, government) balance that SETAC tries to achieve in its operating and membership components. For each LCA Group, a chair is identified from among the elected LCA Group members and recommended for appointment to the SETAC North America and/or SETAC Europe President. Once appointed, this individual will serve a three year term. Other officers (co-chair, communications officer, etc.) of each LCA Group may be designated by the LCA Group as appropriate. Historically, the key to an active and effective LCA Group leadership has been engaging the entire LCA Group members rather than placing the majority of the burden on the chair to organize and run the group.

When initially organized, all LCA Groups prepare a Standard Operating Procedure (SOP) that describes their mission, functional organization, and objectives. In addition, the SOP calls out topics or issues within the purview of the Group and activities, including various communications activities, in which they will be engaged to achieve their goals.

When an LCA Group identifies a number of technical activities within their overall topic, ad-hoc work groups are typically set up to address those issues. Though not a requirement, often the LCA Group members will lead those working groups. For other functions not formally assigned to the LCA Group or taken up by an ad-hoc working group and which are recurring, a standing committee may be formed. Types of activities for which this may be appropriate include, but are not limited to: annual meeting session planning and execution, short courses, webinars, fundraising, etc.

Mission of LCA Groups The general mission of the SETAC LCA Groups is to proactively advance the science and application of LCAs to reduce the resource consumption and environmental burdens associated with products, packaging, processes or activities. To achieve this mission, the LCA Group[10] will:

- Serve as a focal point to provide a broad-based forum for the identification, resolution, and communication of issues regarding LCAs; and,
- Facilitate, coordinate, and provide guidance for the development and implementation of LCAs.

[10] Each LCA Group may have a slightly different mission but generally the purpose is to advance the science and development and application of LCA.

The LCA Group's success in meeting its mission depends on the willingness of its members to voluntarily identify, initiate and conduct activities. At this time, several interest topics have been identified by the current Advisory Group[11].

As noted above, the SETAC LCA Groups are a recognized entity within the SETAC organizational structure. When the proposition was put forth to recognize LCA Groups, it was with the anticipation they would become forums for advancing activities within the Society around certain professional interest areas. In addition, within a 'bottom-up' organization such as SETAC, a geographically oriented Group could deal with regional issues and at the same time represent those regional perspectives on a global stage. It was expected that, given the concentration of technical expertise, the SETAC LCA Group would speak out officially in the name of the Society on occasion within the topical coverage of the Group. In addition to serving its members, a primary goal of SETAC is to provide balanced, scientific information to planners, legislators, managers, regulators, and others. It would further assist in the development of technically sound environmental policies, laws, and regulations.

4.2 LCA Group Activities

SETAC's LCA Groups have successfully held workshops and conferences and have developed pertinent educational material, including 'position papers'. The following sections outline several of the LCA groups' workshops and successes.

4.2.1 A Technical Framework for Life Cycle assessment. August 18–23, 1990, Smugglers Notch, Vermont

Although life cycle assessment promised to be a valuable tool in evaluating the environmental consequences of a product, process, or activity, the concept was relatively new and required a framework for further development.

The workshop, 'A Technical Framework for Life Cycle Assessments' (Fava et al. 1991)', held August 18–23, 1990, at Smugglers Notch, Vermont, was organized by SETAC to develop a framework and consensus on the current state of LCA and research needs for conducting life cycle assessments. Although life cycle assessments have been used, in one form or another, before the name was coined, this workshop report is the first document which presented the name of the method.

The workshop involved 54 scientists and engineers of diverse technical backgrounds representing governmental organizations, universities, industries, public

[11] Recent topics of interest that are being considered for the Advisory Group, include: US Green Building Council's LEED program to identify sustainable buildings; US Database project to make inventory data publicly available; Creation of LCA sessions at the annual SETAC meeting; Liaison with the various task forces within the Life Cycle Initiative; Development of an awards program to recognize exemplary contributions in the field; and, to Identify opportunities for capacity building in developing countries.

interest groups, consultants, and contract research firms. Also, participants were invited from Europe, Japan, and Canada.

The workshop focused on defining concepts and developing a framework for the inventory component of an LCA. However, it also identified the need to conduct particular workshops to evaluate other LCA components.

Workshop Objectives 'A Technical Framework for Life Cycle Assessments' workshop objectives were:

- to clarify definitions and terms associated with life cycle assessments;
- to provide a forum for information exchange among researchers from government, industry, academia, and public interest groups; and,
- to agree on a technical framework of key life cycle assessment components.

The charge given to workshop participants was agreement on a technical framework of key life cycle assessment components and identification of the research needed to improve life cycle assessment techniques.

Workshop Format During the initial phase of the workshop, keynote presentations on the development and use of life cycle assessments were made by individuals representing SETAC, U.S. Environmental Protection Agency, Environmental Defense Fund, state governments, and industries. The objective of this initial phase was to establish a common information base.

Prior to the workshop, each participant was asked to prepare a list of issues and thoughts related to improvement of understanding and development of life cycle assessments.

Participants were placed in one of six workgroups: Raw Materials Acquisition; Processing, Manufacturing, and Formulation; Distribution and Transportation; Use/Re-Use/Maintenance; Waste Management; and Integration.

Report Organization The workshop report presents a general technical framework from which specific methods and procedures could be developed.

Chapter 1 presents an overview of the technical framework for life cycle assessments and a historical perspective on life cycle assessments. Chapter 2 provides an overview of the framework for life cycle inventories. Specific discussions on aspects of the life cycle inventory component (Component I) are presented for Raw Materials and Energy (Chap. 3); Manufacturing, Processing, and Formulation (Chap. 4); Distribution and Transportation (Chap. 5); Use/Re-Use/Maintenance (Chap. 6); Recycling (Chap. 7); and Waste Management (Chap. 8). The research needed to improve the inventory component of a life cycle assessment is discussed in Chapter 9. Research directions and technical considerations necessary to advance the technical framework into Component 2 (Impact Analysis) and Component 3 (Improvement Analysis) are discussed in Chapter 10.

Appendix A is a glossary of the technical terms used in the workshop report. Appendix B is a complete list of participants in the workshop, and Appendix C contains references and a bibliography of reports on Life Cycle Assessment.

Main Findings One of the major findings of the workshop was consensus that complete life cycle assessments should be composed of the following three separate but interrelated components:

- Life cycle inventory
- Life cycle impact analysis
- Life cycle improvement analysis

The three components represented the first attempt to develop a structure for a life cycle assessment and provided the information needed to maximize environmental improvements. This structure has been traded as 'SETAC triangle'.

The existing life cycle assessments focused on the inventory component. As such, most of the participants addressed the life cycle inventory component of a life cycle assessment. Therefore, considerable research was necessary to develop the impact and improvement analysis components.

Participants developed a technical framework for the key phases of a life cycle inventory. The major life cycle inventory stages are (1) raw materials acquisition; (2) manufacturing, processing, and formulation; (3) distribution and transportation; (4) use/re-use/maintenance; (5) recycling; and (6) waste management.

One major finding was related to the question of aggregation of individual environmental release quantities. The workshop participants agreed that the summation of dissimilar materials in the life cycle inventory is scientifically unjustified and represents an incorrect technical approach in the inventory component of a life cycle assessment. However, it was agreed that some summations are possible; for example, summing the same pollutant emitted from different sources, but in the same form and to the same sector of the environment. Also, some categories of data (i.e., solid waste, energy consumption) can be summed (as long as individual data are also provided).

While confidential or proprietary information must be protected, the workshop concluded that methods and data from a life cycle inventory should be available for public review if the document is to be used in the public domain in a decision-making context.

Presentation of quantitative data should include an identification of data sources and the extent of data completeness and variability. Whereas, categorization of data may be employed, aggregation of data should be avoided whenever feasible, and dissimilar data should not be aggregated. It was recommended that a review of national and international standards and other possible conventions be undertaken to generate general guidelines for data grouping.

Research Needs The following specific research needs to improve the life cycle inventory methods were identified during the workshop:

- *Database development,* including: the development of data quality standards; development of generic databases and guidance on when and how they should be used; evaluation of how industry average data should be used in life cycle inventories; and, development of additional databases.

- *Inventory methodology refinement,* including*:* Criteria and applications guidance to determine what level of input and output data is meaningful; establishment of a standard list of waste sources and pollutants; development of generic models; development of approaches to allocate inputs and outputs among co-products; development of approaches to allocate energy and environmental releases among incoming waste streams and to all environmental media; development of approaches to incorporate data variability; development of approaches to take into account sensitivity analysis in life cycle inventory methodology; establishment of a peer review process; standardization of life cycle inventory methods; and, development of effective approaches for communicating life cycle inventory results.

Recommendations The following recommendations came from 'A Technical Framework for Life Cycle Assessments' workshop:

- A multiyear research initiative is needed to ensure the continued development of effective life cycle assessment strategies and methods;
- Initial efforts should focus on refining thelife cycle inventory component;
- Additional efforts should include development of approaches to help progress beyond the inventory to the impact and improvement analysis components of a life cycle assessment;
- Sufficient case studies should be developed to demonstrate the usefulness of life cycle assessment methodology to a wide range of products, processes, and activities;
- The research initiative should be expanded to include applications of the life cycle assessment methods to illustrate their use in actually improving products, processes, and activities; and,
- This new research initiative should build upon and enhance relevant existing pollution prevention research activities.

4.2.2 Life Cycle Assessment: Inventory, Classification, Valuation, and Data Bases. December 2–3, 1991, Leiden, The Netherlands

One month after the workshop at Smugglers Notch, Vermont (August 1990), a European workshop took place in Leuven, Belgium, September 24–25, 1990, on 'Life Cycle Analysis for Packaging Environmental Assessment' (SETAC Europe 1990). Due to the increasing problems of waste disposal, packaging was the main topic of the existing LCAs. The workshop followed a similar aim as the workshop in Smugglers Notch, which was to bring together the groups working on life cycle based assessment methods. This was necessary on both sides of the Atlantic Ocean, since the methods were not really new, but uncoordinated and distanced from harmonization as well as standardization (Klöpffer 2006).

The Workshop in Leiden, The Netherlands The workshop in Leiden, The Netherlands, was chaired by Helias A. Udo de Haes, Centre of Environmental Science

(CML), Leiden University. Approximately 50 participants from Europe and North America attended.

During the Leiden workshop, a discussion occurred about the general set-up of environmental LCA.

First, it was concluded that the term LCA can best be interpreted as 'life cycle assessment' instead of 'life cycle analysis', including both objective and normative steps. Second, different sections of the environmental LCA procedure were identified: goal definition, inventory, impact analysis, valuation. They contribute to the 'improvement options'.

Significantly, the following issue was raised at the workshop: the class of studies called life cycle assessment of products (LCA) might be subdivided into the following interrelated subclasses:

- environmental life cycle assessment
- economic life cycle assessment
- social life cycle assessment

Today, sustainability is discussed as the ultimate goal of LCA. In the 'three pillar' interpretation of sustainability, environmental, economic and social aspects have to be considered. In life cycle product assessment, LCA deals with the environmental aspects only. For the complete assessment, however, the economic and social life cycle aspects have to be included as well (Finkbeiner et al. 2010; Klöpffer 2003, 2008; O'Brien et al. 1996; Valdivia et al. 2012). The 'three pillar' concept of sustainability is often called the 'triple bottom line'.

$$\text{LCSA}=\text{LCA}+\text{LCC}+\text{SLCA}$$

LCSA: Life Cycle Sustainability Assessment
LCA: (environmental) Life Cycle Assessment
LCC: (environmental) Life Cycle Costing
SLCA: Social Life Cycle Assessment

Results. The workshop showed that the LCA methodology was acknowledged to some extent, but confidence and experience with it were still lacking.

4.2.3 A Conceptual Framework for Life Cycle Impact Assessment. February 1–7, 1992, Sandestin, Florida

To develop a consensus on the state of the practice and research needs for conducting life cycle impact assessments, approximately 50 experts in LCA and environmental impact assessment assembled for a 1-week workshop. The workshop was held February 1–7, 1992, in Sandestin, Florida, USA.

The Life Cycle Impact Assessment Workshop marked the first time that the SETAC offices in Europe and the United States shared responsibility in identifying and bringing together international experts for a Pellston workshop (the workshop was

the twelfth in a series of Pellston workshops). The participants represented state and federal agencies, industry, universities, public interest groups, and research laboratories in the United States, Canada, United Kingdom, Belgium, Denmark, France, Germany, and The Netherlands.

The Workshop The workshop objectives were to define impact assessment in the context of an LCA, to discuss and develop a consensus by what means impact assessments could be applied to LCAs, and to assess the overall need for developing feasible impact assessment methods for LCAs. In addition, research needs were identified to improve the impact assessment component of LCAs.

The workshop followed a three-phase format. During the initial phase, discussion initiation papers were presented covering three general areas: LCA background, life cycle impact assessment approaches, and impact assessment methodology. During phase 2, small work group sessions identified and discussed impact categories. During phase 3, the individual work groups[12] identified and discussed the existing impact assessment methods, their potential applications to LCAs, and research needs.

Prior to the workshop, each participant was asked to prepare a list of issues and thoughts related to improving our understanding and developing the life cycle impact assessment component.

Each work group was responsible for developing a summary of the findings discussed during the week. The Steering Committee was responsible for synthesizing the findings of the work groups into a unified report.

Objectives The workshop participants were charged with defining impact assessment in the context of life cycle assessment. Additionally, they were asked to discuss and develop a consensus on whether and by what means existing impact assessment tools could be applied to LCAs. For those areas where consensus could not be reached, the participants were asked to identify research needs to improve the impact assessment component. Although the impact assessment component is still in an early stage of development, a number of existing impact assessment tools were identified that might be applied to LCAs.

Major Findings It was agreed that conducting an LCA is not a linear process but one that incorporates feedback loops and requires interaction among the LCA components. The workshop participants reaffirmed the value of the three-component model for LCAs developed at the Smugglers Notch workshop in 1990. Also, building on the results of the Leiden workshop in 1991, a goal definition and scoping component was incorporated as an additional step which would serve to specify the purpose and expected products of the study, select boundaries, define assumptions, and determine what is to be included or excluded consistent with the goal of the study. Figure 2.1 shows the amended 'SETAC triangle' 1992. Differing from the workshop in Leiden in 1991, the improvement component was included in the technical framework.

[12] The six work groups were human health, ecological (chemical) stressor, ecological (nonchemical) stressor, resource depletion, valuation, and integration.

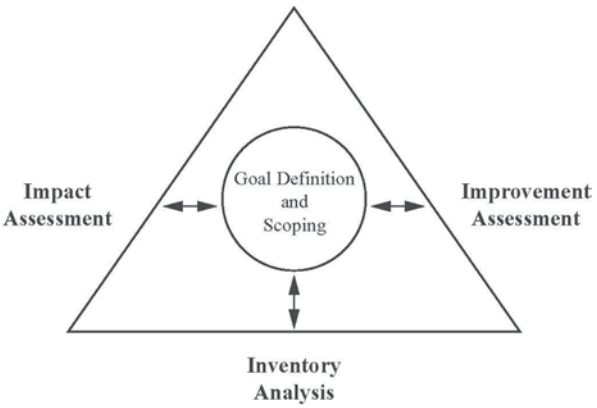

Fig. 2.1 SETAC triangle 1992 (Sandestin workshop) and 1993 (Sesimbra workshop) until the ISO standardization process when 'Improvement assessment' was replaced by 'Interpretation'

The major impact categories were defined. The primary impact categories were human health, ecological health, and resource depletion[13]. Other impact categories were human health, ecological health, and resource depletion impacts associated with changes in social welfare aspects. Occupational health considerations were included within the human health category.

Based on discussions at the workshop and during the SETAC Europe workshop in Leiden, the workshop participants agreed to a three-step conceptual framework for impact assessment as follows:

1. *Classification*—The process of assignment and initial aggregation of data from inventory studies to relatively homogenous stressor categories (e.g., greenhouse gases or ozone depletion compounds) within the larger impact categories (i.e., human and ecological health, and resource depletion).
2. *Characterization*—The analysis and estimation of the magnitude of impacts on ecological health, human health, or resource depletion for each of the stressor categories, derived through application of specific impact assessment tools.
3. *Valuation*—The assignment of relative values or weights to different impacts and their integration across impact categories to allow decision makers to assimilate and consider the full range of relevant impacts across impact categories.

This three-step impact assessment model further developed the two-step impact assessment model discussed during the Leiden Workshop. One of the significant findings was the importance of the stressor concept to bridge the gap between the inventory and impact assessment components. A stressor was defined as a set of conditions that may lead to impacts. The valuation phase, which assigns value or relative weights to the various impact categories, was judged to be inherently subjective.

[13] In today's terminology, primary impact categories are considered Areas of Protection (AoP).

Summary and Future Work The participants recognized that impact assessment is still in an early stage of development and identified a number of research initiatives to enhance the science, practice, and application of LCAs:

- A multi-year research initiative is needed to ensure the development of effective life cycle impact assessment tools and LCA methods in general.
- Case studies should be developed demonstrating the usefulness of the impact assessment steps (i.e., classification, characterization, and valuation), either individually or combined, when applied to a wide range of products, packages, processes, and activities.
- Scoping processes used in other applications should be critically evaluated for their application to LCAs.
- Research is needed to evaluate the cause-and-effect relationship between pairs of stressor-impact linkages relevant to ecological and human health impacts.
- Evaluation of methods to quantify the resource depletion impact category is needed.
- Approaches to applying various decision theory methods to LCAs should be examined.
- The role of social activities and their influence on ecological, human health, and resource depletion impacts should be further considered and approaches to incorporating these impacts in LCAs should be evaluated.

4.2.4 Data Quality: A Conceptual Framework. October 4–9, 1992, in Wintergreen, Virginia

This workshop was the 14th in a series of Pellston-type workshops and the fourth in a series to develop the science, practice, and application of LCAs, in continuation of the workshops in Smugglers Notch (1990), Leiden (1991) and Sandestin (February 1992) (Fava et al. 1994).

To develop a consensus on the state of the practice and research needs for conducting life cycle data quality, approximately 50 experts in LCA and environmental data quality assembled for a one-week workshop. The workshop was held October 4–9, 1992, in Wintergreen, Virginia, USA. The participants represented state and federal agencies, industry, universities, consultants, public interest groups, and research laboratories in Canada, the United States, the United Kingdom, Belgium, Denmark, France, Germany, Japan, Norway, Sweden, Finland, and the Netherlands.

Workshop Objectives The workshop objectives were to:

- identify and understand existing approaches to address data quality issues in LCA studies;
- identify and understand existing approaches to address data quality issues relative to environmental, human health, energy, and resource issues;
- develop a suggested data quality framework considering a distinction among an ultimate framework and steps that can be taken to improve data quality in the

near term and the current state-of-the-practice, recognizing different applications and communication needs;
- develop research needs to improve the quality of LCA data and reduction techniques; and
- begin a process to solicit interest in developing a commitment by users and practitioners to develop LCA integrated international data bases.

Workshop Format As in the case of Smugglers Notch and Sandestin, the workshop followed a three-phase format. The initial phase included the discussion of an initiation paper presented that covered three general areas, namely LCA background, data quality approaches, and data quality assessment methodology. Phase 2 included small workgroup[14] sessions which identified and discussed data quality issues. Phase 3 saw individual workgroups which identified and discussed what data quality assessment methods existed, their potential applications to LCAs, and research needs.

Major Findings Data quality was defined as the degree of confidence with individual input data and in the data set as a whole and ultimately in decisions made by using the data. The reliability of LCA conclusions as final results depends on the quality of the input data and the way they are processed into results using an LCA methodology. The emphasis in this report is on input data.

The workshop provided a strong statement that data quality assessment (DQA) is an integral part of LCA. DQA is a systematic approach to identifying and applying measurements of the suitability of LCA data to meet the intended purpose. Data quality assessment techniques applicable to LCA include the data quality goals (DQGs) process. This process specifies provision for clarity and simplicity in stating data and process related requirements and the establishment of measures of performance to assess data quality.

Use of the DQG process enhances communication, provides a structure for augmenting existing data sets, leads to a focused set of data requirements, and defines the resulting uncertainty of the study results.

The level of data quality achieved is dependent on the level of effort that is allocated to the study, to each subsystem, and to each variable. The appropriate level of effort is influenced by the study purpose, budget and time constraints, data availability, and the need to maintain scientific integrity.

The data quality assessment framework is needed because data in an LCA are diverse and should be assessed by using a logical, formalized, and repeatable method. The framework allows for data documentation in a flexible manner, using quantitative or qualitative measures.

There are many approaches to evaluate data quality. Two were identified as illustrating key issues: qualitative evaluation using a matrix approach, and quantitative evaluation using value trees.

[14] The six workgroups were data quality framework, materials, energy, environmental emissions, ecological health and exposure, and human health and exposure.

In conducting a data quality assessment, it was recommended that sensitivity analysis be used to direct and select the expenditure of time and money to those areas most likely to improve the overall quality of the study. In general, peer review has been used more to ensure the quality of data collection and manipulation procedures than to ensure the quality of the raw data. It was recommended that the current practice be reviewed to establish areas where further enhancements of the peer-review process could be made. Moreover, it was recognized that due to differences in development between the inventory and impact components of LCA, it is likely that more definitive Data Quality Indicators (DQIs) may be established for the inventory analysis.

Research Needs Research needs identified during the workshop can be grouped into three general categories:

1. data quality assessment framework development;
2. data and data base development; and,
3. mathematical models advancement.

4.2.5 Code of Practice. Sesimbra, Portugal, March 31–April 3, 1993

Considering the four SETAC LCA workshops in Smugglers Notch (1990), Leiden (1991), Sandestin (1992) and Wintergreen (1992), it is noticeable that they formed a tiered process to culminate in the workshop of Sesimbra, Portugal, March 31–April 3, 1993.

The European and North American organizations of SETAC planned and conducted the LCA 'Code of Practice' Workshop in Sesimbra, Portugal. It was, after the workshop in Leiden, the second cooperative effort of the two SETAC LCA Advisory groups and the fifth technical workshop on LCA. Fifty experts from 13 countries were invited to define the LCA method and discuss its various possible applications.

Allan Astrup Jensen and Dennis Postlethwaite reported: "There were some 50 participants, deliberately selected to represent a wide range of views and opinions and to include a full representation of all interested parties—from Institutes, Governmental Bodies, Academia and Industry. The participants, and especially the organizing committee, worked very hard, such that the first report draft was circulated for comment by April 5th—quite a remarkable achievement. This draft was further debated and discussed by all participants, after which it was presented to a wider audience at Open Forums held in Europe and the United States. The final document, which incorporated significant points and amendments from these meetings, was published in the autumn of 1993. Because of legal implications in the US, the title had to be changed to a Guideline for Life Cycle Assessment with the subtitle: A Code of Practice [instead of 'Code of Conduct', as planned originally]. It was planned that an additional, longer and more methodological report should be made based on the Sesimbra discussions but, because of other pressures, this failed to materialize, much to the disappointment of several participants."

Objectives The 'Code of Practice' is not a standard for conducting LCAs. It provides guidance on process and methodological aspects of conducting LCAs reflecting the current situation, namely the status in 1993 which concerned the following issues:

1. LCA is a complex, multi-dimensional tool.
2. The LCA methodology has yet to be fully described. Of the three LCA components, only the Life Cycle Inventory Analysis has been well documented. The Life Cycle Impact Assessment methodology remains in development, and the Improvement Analysis has yet to be described conceptually.
3. The state-of-the art in 1993 is Life Cycle Inventory (LCI) and improvement of environmental performance based on LCI information.
4. New issues arise as practitioners continue to gain knowledge and experience on the application of LCA.

The 'Code of Practice' reaffirmed the findings of the Sandestin workshop, which, on its part, was an evaluation of the two workshops in Smugglers Notch (1990) and Leiden (1991). The reaffirmation concerned the technical framework with the components goal definition and scoping and inventory analysis as part of the framework, as well as the three-step impact assessment model, the impact categories.

The 'Code of Practice' was intended as guidance for all individuals who commission, carry-out, review, or use the results of an LCA, and should be used to enhance the quality, transparency, and credibility of such studies.

Peer Review Process For the first time, the 'Code of Practice' recommended and described a peer-review process to be a key feature in the advancement of LCAs, because it would enhance the scientific and technical quality of LCAs, help to focus study goals, data collection, and provide a critical screening of study conclusions, thereby enhancing study credibility.

The LCA peer review was relatively new and had not been fully tested and optimized. The 'Code of Practice' recommended that it should be more extensive than that traditionally used for the publication of research in scientific journals, for the following reasons:

- Because some LCA applications have regulatory and public-policy implications, a broad consultative approach is desirable in the review process to reach conclusions.
- Where proprietary information is used in LCA studies to reach conclusions that will be made public, protection of the proprietary information requires novel methods of peer review.
- The complexity of the data collection/definition and of the LCA process requires a more multidisciplinary peer review process than is required in most scientific studies.

Furthermore, the 'Code of Practice' recommended an interactive peer review process at various stages of the study for LCAs directed toward public audiences; this strategy can ensure the credibility of the study.

This interactive peer review ideally should be carried out in three phases:

Phase 1: at the beginning of the LCA to review the goals, scope, boundaries, and the data collection planned;
Phase 2: after initial data collection or modelling, to review the progress and offer advice or comments; and
Phase 3: at the final report stage, to review the adequacy of the study and the credibility of the conclusions.

While the three-phase peer review process is desirable, in some instances only a review of the final study report and supporting data may be possible ('a posteriori' peer review). The ISO 14040 (1997) did not make a recommendation for one form or the other. The 'Code of Practice' was more 'modern' in that respect and also described the review process in more detail (Klöpffer 1997, 2005, 2012).

Future Research Needs The identification of future research needs is a continuing process. One objective of the international SETAC LCA workshops was to identify such requirements. Initial needs were identified as follows:

- Data quality and database development;
- Methodology development (notably generic model development), allocation, energy accounting, and communication;
- Minimization of differences between methodologies;
- Gaining of public acceptance of the LCA concept and applications via communication and education;
- A code of conduct for undertaking LCAs.

ISO Standardization Developing international consensus on harmonized methods has been a goal of the SETAC LCA workshops. The 'Code of Practice' completed the harmonization process. Shortly after the workshop, during the autumn of 1993, the ISO standardization process was initiated.

4.3 SETAC LCA Workgroups from 1994 to 2000

In 1994, as a result of the SETAC LCA workshops, the LCA Advisory Group of SETAC and the LCA Steering committee of SETAC Europe[15] established individual work groups to address specific LCA issues.

'In this connection, it should be mentioned that the role of the steering/advisory LCA committees cannot be overestimated. The working groups are installed and supervised by these committees which also prepare the regular LCA sessions at the annual SETAC and SETAC Europe meetings, decide about publications, etc.' (Klöpffer 2006).

[15] LCA advisory group in the USA, LCA steering committee in Europe.

The following reports were developed and published by SETAC LCA workgroups before the year 2000:

- Towards a Methodology for Life Cycle Impact Assessment. SETAC Europe 1996 (Udo de Haes 1996)
- Simplifying LCA: Just a Cut? SETAC Europe 1997 (Christiansen 1997)
- Life Cycle Impact Assessment: The State-of-the-Art. SETAC (NA) 1997,1998 (Barnthouse et al. 1998)
- Streamlined Life Cycle Assessment SETAC (NA) 1999 (Todd and Curran 1999)

Thus the two topics, Life Cycle Impact Assessment (LCIA) and streamlined/simplified LCA, were addressed from SETAC Europe and SETAC North America respectively.

SETAC Europe Report: Towards a Methodology for Life Cycle Impact Assessment. September 1996

Report of the SETAC Life Cycle Assessment (LCA) Impact Assessment Workgroup, SETAC LCA Advisory Group: Life Cycle Impact Assessment—The State-of-the-Art 1998

The SETAC workshops in Sandestin, 1992 (Fava et al. 1993) and Sesimbra, 1993 (Consoli et al. 1993) revealed that, according to the current situation of that time, the component 'Life Cycle Impact Assessment' (LCIA) was still in development:

- Classification: Defined; requires further work
- Characterization: Conceptually defined and partly developed
- Valuation: Conceptually defined; different methods and approaches currently being used

Walter Klöpffer (Klöpffer 2006) commented: 'The methodology had to be discussed in a broader context and with a larger public. The occasion was the fourth SETAC Europe Annual Meeting in Brussels, in April 1994, during which a special symposium on LCIA was organized and published as a SETAC Europe Report'.

Moreover, the Life Cycle Impact Assessment workgroup of the LCA Advisory Group of SETAC and that of the LCA Steering Committee of SETAC Europe prepared two individual reports on LCIA.

The reports can be seen as complementary documents. They elaborate strong similarities but also a limited number of different positions. The latter 'will need continued discussion to be resolved as additional experience is gained'.

The SETAC Europe work group focused primarily on comparing methodologies and recommending methodological improvements, especially in the area of resources, normalization, and certain aspects of valuation. It refers to the results of the Leiden Workshop (1991).

The SETAC work group effort has resulted in a fundamental examination of the basic strengths and weaknesses of the Sandestin framework (1992). This has led to a number of significant insights, e.g., LCIA's being an indicator system. It has also seen the need to address uncertainty, to reach the understanding that LCIA indicators do not necessarily represent actual and significant differences between systems,

and to integrate LCA with other analytical techniques and decision tools. This work group did not evaluate particular methodologies for any category.

Areas of Consensus

- Life cycle impact assessment deals with mass loadings as aggregated emissions and cannot assess actual impacts.
- Life cycle impact assessment is a simplified indicator approach.
- Risk assessments or Sandestin 'level 5' site-specific assessments are absolute in nature and cannot be conducted from relative LCA data after the functional unit and other inventory calculations.
- Spatial and temporal discontinuities exist between LCA and a number of environmental processes that affect the reliability and environmental representativeness of LCA information.
- There are interpretative implications of using LCA assumptions in representing environmental processes.

Issues Addressed by One Workgroup and not the Other The North American SETAC work group addressed:

- The identification and points of use of subjective judgments in classification and characterization.
- The integration of LCA results with other techniques and information.
- The need to address uncertainty in LCA and to distinguish differences between systems other than using point estimates based upon averages.
- The need to develop a better understanding of peer or critical review processes in regards to LCIA.

The SETAC Europe work group addressed:

- A concentrated effort to compare methodologies.
- A more detailed discussion of resource use methods.

Issues Where There May Be a Lack of Consensus The North American work group did not envision a default list of categories. One was apparently suggested by the European work group (see Table 2, page 15 in the SETAC Europe report). The North American work group was sceptical that a generic set of valuation weighting factors can be developed. However, the European work group was more optimistic.

SETAC Europe Report: Simplifying LCA: Just a Cut? Final report from the SETAC Europe LCA Screening and Streamlining Working Group. Editor: Kim Christiansen. May 1997

Streamlined Life Cycle Assessment: A Final Report from the SETAC North America Streamlined LCA Workgroup. Edited by: Joel Ann Todd and Mary Ann Curran. July 1999

In 1994 the LCA Steering Committee of SETAC Europe established a series of work groups, including the Workgroup Screening and Streamlining. In the same year, the SETAC North America workgroup on Streamlining LCA was initiated. Both groups concluded their multi-year efforts on the issue of Simplifying/Streamlining by a report in each case. The approaches of the reports were different.

The report of SETAC Europe discussed the methods for producing simplified procedures, commonly described as screening LCA studies, streamlined LCA studies and simplified LCA studies. The report of SETAC North America was more a description of carefully planning and stating an LCA's goal than it was about Streamlined LCA methodology. As can be seen from the two reports of the LCIA groups, the European position was more practical, while the USA point of view concerned the more theoretical, superordinate system.

Report of the LCA Steering Committee of SETAC Europe

Simplified LCA is an application of the LCA methodology for a comprehensive screening assessment. A simplified LCA should cover three steps which are iteratively interlinked:

1. Screening: identifying those parts of the system (life cycle) or of the elementary flows that are either important or have data gaps.
2. Simplifying: using the findings of Screening in order to focus further work on the important parts of the system or of the elementary flows.
3. Assessing reliability: checking that simplification does not significantly reduce the reliability of the overall result.

Simplifying methods can reduce the complexity of an LCA and so reduce the cost, time and effort required, by exclusion of certain life cycle stages, system inputs or outputs or impact categories, or use of generic data modules for the system under study.

Report Organization

- Chapter 1 introduces the issues of screening and simplifying in LCA.
- Chapter 2 lists the definitions on screening and simplifying concepts used in this report.
- Chapter 3 continues the introduction by developing the framework for the three-step process of simplifying an LCA and discussing each in detail.
- Chapter 4 discusses the reporting of a simplified LCA.
- Chapter 5 presents a series of examples.
- Chapter 6 presents the conclusions and recommendations from the workgroup for further work in the area of simplifying LCA.

Application of Methods: Simplification The goal and scope definition should not be simplified itself. Goal definition, as such, cannot be reduced to defining the goal of a simplified LCA as a goal definition. The scope definition, similarly, cannot be minimized, but the borders of the product system can be set to give a simplified picture of the product system. It is, however, important to remember that the first step of this procedure, screening, should cover the product system from cradle-to-grave (i.e., be comprehensive). Regarding available data, both the main processes and ancillary processes are significant to the product system.

The life cycle inventory analysis phase offers the greatest scope for simplification. It primarily involves the use of readily available data representing the product system at a generic and not system-specific level.

In the life cycle impact assessment phase, many of the classifications, characterizations and weighting methods available are already simplified versions of much more detailed environmental assessment approaches. Yet, the selection of impact categories, the impact data applied, etc. can sometimes be narrowed down without losing the overall quality and reliability of the LCA study. Simplifying the life cycle inventory analysis will imply a simplification of the life cycle impact assessment.

The life cycle interpretation phase can only be simplified with great caution. Interpretation as described by ISO/CD 14043 is a simplification procedure in itself, for the benefit of a more understandable and assessable result of the life cycle inventory analysis and/or the life cycle impact assessment. LCA expertise, as well as product system expertise, is still needed in the interpretation.

Report of the SETAC North America Workgroup on Streamlining LCA

Streamlined LCA: Identification of elements of an LCA that can be omitted or where surrogate or generic data can be used without significantly affecting the accuracy of the results.

Streamlining LCA is a practice to make a detailed/full LCA more manageable. Streamlining LCA can be achieved in a number of ways, including:

- Limiting the scope in terms of time, cost, data, analytical approach: for example, eliminating life cycle phases deemed not significant, or processes with negligible effect on the environment;
- Use of qualitative information;
- Removal of upstream and/or downstream components;
- Use of specific impact category.

Streamlining is an inherent part of any LCA. The key is to link the streamlining activities closely with the goal and scope definition process. That is, streamlining is a routine element of defining the boundaries and data needs of a study and is not in itself a different approach or methodology for LCA. In other words, ‘full-scale’ LCA and ‘streamlined’ LCA are not two separate approaches but rather two points on a continuum.

Report Organization The report consists of 4 chapters:

- Chapter 1 is a short introduction to LCA and the issues surrounding simplifying the process.
- Chapter 2 describes the important role of the goal-and-scope definition process in streamlining decisions.
- Chapter 3 describes approaches to streamlining.
- Chapter 4 offers some concluding thoughts on streamlined LCA methods.

The purpose of this report is to:

- redefine streamlining as an inherent part of any LCA approach that involves deciding what is and what is not to be included in a study;
- emphasize that streamlining steps must be consistent with the original study goals and anticipated uses;

- describe various ways that streamlining LCA has been attempted and investigated and the possible implications in different decision-making contexts; and
- provide recommendations on how the goal-and-scope definition process can be used to design and streamline an LCA study.

The workgroup and thus the report have also benefitted from the work of the SETAC Europe Workgroup on Streamlining and their report 'Simplifying LCA: Just a Cut?'

Within the workgroup, however, consensus has not been reached on the exact methods and procedures that can be used in a streamlined LCA or on appropriate uses of a streamlined LCA.

4.4 SETAC LCA Workshops and Initiatives up from 1999

In 1994, the SETAC Europe LCA steering committee and the SETAC (North America) LCA advisory group established, amongst others, the workgroups on Life Cycle Impact Assessment and Simplified/Streamlined LCA. These workgroups published four reports (see Sect. 4.3 'SETAC LCA workgroups from 1994 to 2000').

Walter Klöpffer (2006) focused in his article on the workgroups on Life Cycle Impact Assessment (LCIA), due to the complexity of the issue and the difficulties arising from the somewhat different approaches of the LCIA workgroups (SETAC Europe and SETAC North America); they are defined in the Sect. 4.3 'SETAC LCA workgroups from 1994 to 2000').

According to Klöpffer it transpired that the European efforts towards a unified LCIA methodology did not get acceptance by the global LCA community. Sessions on LCIA were organized at the annual meetings following the Brussels (4th) annual meeting in 1994 (Udo de Haes et al. 1994).

The LCIA issue was followed up in a group chaired by Helias Udo de Haes. Subgroups had to be formed to handle the broad topic. Within one year, the framework paper was published in Int J Life Cycle Assess (Udo de Haes et al. 1999a, b) in the form of two reports. They constitute a basis for the identification of best available practice concerning impact categories and characterization factors for Life Cycle Impact Assessment. The reports are the result of the first working phase of the second workgroup on Life Cycle Impact Assessment of SETAC Europe. In this workgroup members from other divisions of SETAC participated, in particular from the USA and from Japan.

Thus, the framework paper was ready to be discussed during the SETAC Europe 1999 annual meeting in Leipzig. A discussion with SETAC members from North America took place as well, even publicly (Owens 1998, 1999). The framework paper was finally ready for review in the end of 2001 and published by SETAC Press 2002 in the award-winning book 'Life Cycle Impact Assessment: Striving Towards Best Practice' (Udo de Haes et al. 2002a).

During the period from 1994 to 2000 (first wave of workshops, see section *'SETAC LCA workgroups from 1994 to 2000'*), another workshop took place and was published by SETAC:

4.4.1 Application of Life Cycle Assessment to Public Policy, August 14–19, 1995, Wintergreen, VA, USA

Public Policy Applications of Life Cycle Assessment. Proceedings from the Workshop on 'Application of Life Cycle Assessment to Public Policy', 14–19 August 1995, Wintergreen, Virginia, USA. Edited by David T. Allen, Frank J. Consoli, Gary A. Davis, James A. Fava, John L. Warren.

The life cycle concept is a powerful systems approach for thinking about technology from a 'cradle-to-grave' perspective. Life cycle assessment (LCA) is one analytical tool for implementing life cycle concepts. Use of life cycle concepts and tools can link scientific, technological, and policy-making communities in an overall effort to find an appropriate balance between economic, environmental, and energy considerations.

Public policies are actions, decisions, statements, mandates, orders, or guidance taken by governmental entities that affect other governmental entities, non-governmental entities, the public, and private interests. Public policies are shaped and constrained by many interests within and outside government, existing policies, legal and societal norms, and institutional arrangements.

Governmental entities include all regulatory and non-regulatory institutions (e.g., programs, agencies, departments) at local, state, regional, provincial, federal, and international levels, across executive, legislative, and judicial branches.

The shift toward more integrative public policy tools is occurring at all levels of government and around the world.

The life cycle concept may improve the public policy process by providing information to decision-makers in a comprehensive manner. Public policy decisions, however, are extremely varied. They range from the implementation of narrow mandates to the development of broad policy statements and involve very different institutions, from local planning departments to federal agencies and the Executive Office of the President. Consequently, the application of the life cycle concept to public policy will involve a broad range of depth, breadth, and rigor.

For life cycle concepts to be widely applied in policy settings, the results must be understandable, transparent, and accessible to all stakeholders. This level of understanding will require an aggressive education and information-dissemination effort.

The objectives of the workshop were to:

- define the public policy arenas in which LCA could inform decision-making;
- develop specific guidance for the use of LCA in public policy;
- specify a framework and approach for LCA use in public policy decisions; and,
- determine future research needs in the application of LCA to public policy-making.

Approximately 40 internationally recognized experts in LCA and the application of LCA to public policy-making were organized into five workgroups. One working group was charged with outlining a framework for the application of lifecycle assessment to public policy. Their report is contained in Chapter 2. The remaining 4 groups considered specific application arenas. Chapter 3 reports on the use of LCA in environmental labeling initiatives. Chapter 4 examines the use of LCA in governmental acquisition and procurement. Chapter 5 considers the use of LCA in analyzing regulations and setting policy, and Chapter 6 probes the use of LCA in identifying environmental technologies.

4.4.2 A Second Wave of LCA Workshops

During the Bordeaux (8th) annual meeting in 1998, a second wave of workgroups was started with a planned duration of three years. Within the SETAC Europe workgroups, several other reports were published:

- Code of Life Cycle Inventory Practice (Beaufort-Langeveld et al. 2003)
- Life cycle management (LCM) (Hunkeler et al. 2004)
- The working environment in LCA (Poulsen et al. 2004)
- Scenarios in Life Cycle Assessment (Rebitzer and Ekvall 2004)
- Life Cycle Assessment in Building and Construction (Kotaji et al. 2003)

One prerequisite for the cooperation between UNEP (United Nations Environment Program) and SETAC, was the transformation of SETAC into a truly global organization in the late 1990s. Another reason was UNEP's need for implementing sustainable development, proclaimed as the most important goal of humankind in Rio de Janeiro 1992[16] and confirmed in Johannesburg in 2002[17]. Sustainability is based on methods derived from life cycle thinking (Klöpffer 2003), with LCA as the core element. Thus, a co-operation between SETAC and UNEP's Production and Consumption Branch (Paris), was logical and promising. The cooperation between UNEP and SETAC was officially launched on April 28 2002, in Prague (Töpfer 2002).

The key people from SETAC in the negotiations were Jim Fava (Fava 2002), Helias Udo de Haes and Olivier Jolliet (Udo de Haes et al. 2002b). In 2003, The International Journal of Life Cycle Assessment became the associated journal of the Initiative (De Larderel and Fava 2003).

The UNEP/SETAC Life Cycle Initiative is an achievement in significant part due to SETAC. With this success, however, several areas (e.g., LCI, LCIA, LCM, traditionally covered by SETAC and SETAC Europe) were now primarily addressed by the Initiative. There is continuing efforts to ensure complementary programs within

[16] United Nations Conference of Environment and Development (UNCED), Rio de Janeiro, June 1992.

[17] World Summit on Sustainable Development, Johannesburg, September 2002.

UNEP/SETAC LC Initiative and SETAC building off the skills, and skills of each group to advance the development and application of life cycle approaches globally.

Klöpffer (2006) scrutinized the future of LCA in SETAC and recommended that SETAC as the scientific arm of the Initiative should continue to take the leadership in LCA. In this connection he pointed to two workgroups "which may be especially promising for further 'cutting edge' activities":

- Life Cycle Costing
- Input-Output and Hybrid Life Cycle Assessment

Another important item in LCA—and a deficiency—would be the inability of LCIA to incorporate non-chemical impacts to ecosystems, e.g., invasive species and certain biotechnologically modified organisms.

Further, 'Sustainable consumption' would turn out to be a field of considerable interest.

Klöpffer (2006) recommends that the SETAC work groups, enacted and surveyed by the LCA advisory/steering committees, should continue to play a major role in the development of life cycle based assessment and management methods.

5 SETAC and the International Organization for Standardization[18]

The International Organization for Standardization (ISO) is the world's largest developer of voluntary International Standards[19]. In the fall of 1993, when ISO was questioning the need for an international life cycle assessment standard, they nominated a small group consisting of SETAC LCA experts and others to develop recommendations to consider whether the LCA standardization should be pursued. The Strategic Advisory Group on the Environment (SAGE) chaired by Jim Fava[20], brought together the international experts on LCA involved in SETAC's LCA Groups and other international experts, to develop the recommendation.

The SAGE recommended that standards should be written on General Principles and the Life Cycle Inventory Phase of LCAs, but suggested that Impact Assessment and Interpretation phases of LCA were not yet developed enough to be included in ISO LCA standards. The two recommended standards were suggested as they already had international methodologies in place and required only harmonization as opposed to development. However, during the first ISO meeting to discuss the LCA standards, overwhelming interest from many countries led to the final decision

[18] See this volume, Chapt. 5 'The international standards as constitution of LCA: the ISO 14040 series and its offspring' by Matthias Finkbeiner.

[19] http://www.iso.org/iso/home/about.htm.

[20] Jim Fava, Chair, at the time Vice President, WESTON Solutions.

that four standards[21] (ISO 14040 to 14044) would be written so that more countries could be involved. While standards based on General Principles and the Life Cycle Inventory Phase of LCAs were developed quickly, the additional two standards, on Impact Assessment and Interpretation were slow to develop as they created the need to develop new methodologies rather than just harmonizing existing ideas. Today, these four original LCA standards have been combined into two.

6 On-Going SETAC Activities

In the years when many North American SETAC members were involved in developing the ISO LCA standards, additional SETAC activities were occurring outside of North America. In Europe, professors and students were developing LCA methodology, leaving other SETAC members to work on both SETAC activities and ISO standard development. SETAC Europe continued developing working groups and addressing various international environmental concerns.

6.1 Global Advisory Groups

The Global Coordinating Group (GCG) was formed in 2011 as a mechanism for communication between the regional Advisory and Steering Groups in North America and Europe to allow the other Geographic Units to have representation in global SETAC LCA affairs. The GCG became the point of membership for all members in the SETAC LCA Community with the switch to the new membership platform.

The two geographic unit level LCA advisory and steering groups were among the earliest established in SETAC. At the time, distinct interests and centres of activity made it appropriate to have separate groups for the two regions. As time went on, LCA became a more global practice and the interests of regional groups more overlapping and intersecting. In addition, LCA practitioners and interested individuals from Latin America, Asia-Pacific, and Africa had no direct voice in the advisory and steering group governance structure existing within SETAC.

The mission of the LCA Global Coordinating Group within SETAC is to encourage and coordinate regional Advisory Group efforts to advance the science, practice, and application of LCAs, and to ensure that a global perspective is maintained toward the achievement of LCA Groups objectives. To accomplish this mission, the Group serves as a focal point to provide a harmonizing forum for the identification, resolution, and communication of issues and activities regarding LCA across geographic units. Further, it facilitates, coordinates, and provides guidance for the development and implementation of LCA methodology and practice in close coop-

[21] The four standards: General Principles of LCA; Life Cycle Inventory Phases of LCA; Impact Assessment LCA; and Interpretation of LCA.

eration with the LCA Groups of SETAC in various regions. As such, it serves as a point of liaison between the SETAC LCA Groups and the SETAC governance role as co-Chair of the International Life Cycle Board of the UNEP/SETAC Life Cycle Initiative.

The Global Coordinating Group's website[22] contains a collection of information on various SETAC LCA topics and provides links to relevant resources.

7 UNEP/SETAC Life Cycle Initiative[23]

In 2002, the United Nations Environment Programme (UNEP), the Society of Environmental Toxicology and Chemistry (SETAC) and partners from governments, academia, civil society, business and industry joined forces to promote life cycle approaches worldwide. This was done to increase resource-efficiency and to accelerate a transition towards more sustainable consumption and production patterns. Sustainable development objectives and a company's bottom line come together in the important topic of assessing and managing the life cycle of processes, materials, products and services.

After the publication of the ISO 14040 standard dealing with LCA (ISO 14040:1997), UNEP and SETAC became aware of the need for dissemination and implementation. They jointly began to engage more partners to work on the articulation of science-based existing efforts around life cycle thinking and established the UNEP/SETAC Life Cycle Initiative (Life Cycle Initiative).

This life cycle partnership for a more sustainable world between UNEP, SETAC and public/private sector partners has the overall objective of promoting, assisting and supporting the application of life cycle thinking and life cycle approaches. This includes life cycle management, life cycle assessment, carbon footprinting and water footprinting, by governments as well as companies and their suppliers, customers and other value-chain partners worldwide. The final purpose is furthering sustainable innovation and global use of more sustainable products.

The Life Cycle Initiative's activities have been carried out in three phases, in which around 2000 members of the global life cycle community have been actively involved.

The first phase (2002–2007) focused on establishing the Life Cycle Initiative as a global focal point of life cycle-related knowledge and activities and building an expert community of practitioners. Activities to move the Life Cycle agenda forward concentrated on three important fields of work:

1. Life Cycle Management (LCM);
2. Life Cycle Inventory (LCI); and,

[22] http://www.setac.org/group/AGLCA.

[23] See also Chap. 6 'The UNEP/SETAC Life Cycle Initiative' by Guido Sonnemann and Sonia Valdivia.

3. Life Cycle Impact Assessment (LCIA) as well as the crosscutting area of social impacts along the life cycle.

At the end of the first phase, a process was started to help create regional and national life cycle networks, particularly in developing countries, to support capability development. Due to the important personal engagement of Greg Norris, today faculty of the Harvard School of Public Health, it was possible to get life cycle networks in Africa and Latin America initiated.

Phase 2 activities (2007–2012) saw the Life Cycle Initiative evolve to be more participative with regard to stakeholders, encouraging more involvement from key actors at the global level. The goal was to achieve common understanding and agreement on tools and strategies being developed. The main outcomes of Phase 2 were accomplished through close collaboration with crucial stakeholders in the field.

In both Phase 1 and 2, the Life Cycle Initiative was able to provide support in the application of sustainability-driven life cycle approaches based on lessons learned from leading organizations by its capacity of engaging with world class experts and practitioners working in product policy, management and development.

The Life Cycle Initiative started Phase 3 in 2012 with a mission to 'enable the global use of credible life cycle knowledge for more sustainable societies'. Its overarching goal is to 'facilitate the generation and uptake of science-based life cycle approaches and information for products and organization by business, government and civil society practice worldwide as a basis for sustainable consumption and production'. Activities in Phase 3 will focus on creating the enabling conditions to: (a) enhance the global consensus and relevance of existing and emerging life cycle methodologies and data management; (b) expand capabilities worldwide and make life cycle approaches operational for organizations; and, (c) communicate current life cycle knowledge and be the global voice of the life cycle community to influence and partner with stakeholders.

8 SETAC's Role in Advancing the Use of LCA in the Building Sector

In the fall of 2004, there was a unique opportunity for two leading organizations to come together and begin a dialogue on the use of life cycle approaches within the building sector. SETAC and the U.S. Green Building Council's (USGBC) Green Build forum both were meeting in Portland, OR, USA, on back to back weeks. This opportunity was well timed, as both the building and construction sector and SETAC had progressed to a point of being ready for collaboration.

At the time, the building and construction sector was beginning to recognize that the impact of building construction and operations was significant and it was obvious that a systems and life cycle approach would support progress in reducing the footprint associated with building material. While the life cycle community had

been able to advance the life cycle methodology, the practical applications to specific sectors was one of the next steps in life cycle advancement. The building sector was a logical sector-specific application of life cycle approaches.

SETAC, USGBC and the UNEP/SETAC Life Cycle Initiative[24] organized a one-day forum in the fall of 2004 entitled "Advancing the use of life cycle approaches by building decision makers." The purpose of the forum was to provide an opportunity to exchange information on LCA and green buildings programs. During these discussions, SETAC and the UNEP/SETAC Life Cycle Initiative provided the North American Green Building community (USGBC, manufacturers, architects, city/state/federal government, consultants, NGOs, academics) with a chance to come up to speed on the current state of LCA applied to construction in Europe, Australia, Latin America and Asia Pacific.

At the same time, the North-American green building community provided members of the life cycle community from Australia, Europe and other regions with an understanding of current events and trends in application and policies related to life cycle approaches to green construction in North America. Additionally, SETAC and the UNEP/SETAC Life Cycle Initiative provided the building community with a description of other international programs and forums. These included the UNEP/SETAC Life Cycle Initiative, the ISO process on updating LCA standards, and the ISO process to develop a framework for assessment of environmental performance of buildings, all of which were shaping LCA and its application to buildings.

These groundbreaking discussions laid the solid foundation necessary for the continued exploration of the application of LCA within the building and construction sector. There was a solid interest in advancing LCA through collaboration within the building and construction sector generally and with USGBC specifically. While details on how to expand the use of LCA within the building and construction sector were not the focus of the workshop, the group felt they were at a critical point related to the use of LCA in advancing Green Building decision making. In the view of one attendee, 'a 15 year old tool has finally found a purpose.'

The ISO 14040 family of LCA standards should be used as a starting point for further development of LCA methodology within the building sector application. The use of LCA tools must also ensure that barriers to trade are not developed. It was also strongly pointed out that, while LCA may be a useful tool to improve green building decision making, it is not the only tool. Other tools and information will be needed to improve green buildings.

Two issues, among others, that surfaced during conversations between the two groups included the need for further examination of a 'functional unit' for buildings, and the pros and cons of performance and/or continuous improvement based

[24] The Advisory Committee for the Forum: Jim Fava, Chair, Managing Director of Five Winds International, and Vice-chair for the UNEP/SETAC International Life Cycle Panel; Deborah Dunning, President, International Design Center for the Environment; Pamela Horner, Sylvania and IESNA; Gregory A. Norris, Sylvatica, and Programme Manager for the UNEP/SETAC Life-Cycle Initiative program; Bob Peoples, Carpet & Rug Institute and CARE; Guido Sonnemann, UNEP/SETAC Life Cycle Initiative Secretariat; and, Wayne Trusty, President, Athena Sustainable Materials Institute.

approaches to using LCA. LCA can now be used at two levels, at the level of the building as a whole and at the level of building materials or products. Experiences obtained so far indicate that the latter is easier than the former, although applications at the building level can also produce useful results and are advancing.

The building and materials market has radically changed over the last ten years or so. In the United States, the Green Building Council (USGBC) developed its LEED® system. In the UK and Germany, similar programs have created the foundation for market transformation. Today there are dozens of Green Building Councils around the world. While the rating systems are not perfect, they have created the capacity to allow architects, designers, and building commissioners to integrate sustainability into the building and construction sector.

9 Future Role of SETAC

As SETAC works to advance the understanding and use of LCA, it will continue to ensure that science is kept in the forefront of LCA development. By doing so, SETAC will continue to help LCA remain credible and trusted. This overarching focus, along with its emphasis on balanced engagement among academia, business and government, will remain in all of SETAC's activities, including those that are highlighted in the following sections[25].

9.1 Expanding the Use of LCA

Although SETAC has advanced the development and implementation of LCA in Europe and North America, it has yet to grow these activities in other geographic areas. Particularly in Africa and South America, SETAC is in the early stages of incorporating LCA into their regional meetings. Connecting the right people is a necessary part of developing LCA in an area currently unfamiliar with it. For example, SETAC is in the early stages of connecting toxicologists with individuals focusing on LCA so that a team with local knowledge can be formed.

9.2 LCA Case Studies

SETAC Europe's Case Study Symposium, which is entering its 19th year, is a forum for LCA professionals to share case studies with an international audience. Although the Case Study Symposium is currently an opportunity to share case study results, there has been interest to evolve the symposium into a platform to assemble

[25] The following sections are based on conversations with Bruce Vigon, Scientific Affairs Manager at SETAC.

and critically examine those results as well. This critical examination will help the LCA community to evaluate the science behind LCA and ensure that LCA remains reputable. As well, it should allow students and early career professionals to share their work.

Rick Wenning, the Editor-in-Chief of Integrated Environmental Assessment and Management (IEAM)[26], has expressed a willingness to increase the presence of LCA in the SETAC Journals. The organizers of the 2012 Case Study Symposium in Copenhagen recently assembled a special issue of the journal that consisted of the top ten symposium papers. Because the issue underwent peer-review as part of the normal publication process, the collection of papers has professional acceptance and is more highly regarded. This, in turn, reflects favorably on the symposium activity. Using this special issue of IEAM as a guide, SETAC can enhance its visibility by publishing peer-reviewed collections from future events.

9.3 Additional Pellston Workshops

The Pellston Workshop format, though proven to be successful over decades, including the purpose of further developing LCA, should be used only when circumstances such as the need for global consensus dictate it. Considering the Pellston Workshop requires such a rigorous effort, one of the other workshop formats that SETAC has developed over the years can often suffice to meet the scientific and publication objectives and be less resource intensive.

In order to require a Pellston Workshop, the workshop topic being covered needs to be worthy of the Pellston brand. This means that the issue needs to be one that is controversial, lacking in the needed consensus, and has a significant research or scientific question that only the rigor of the Pellston workshop is capable of addressing. For example, topics that wouldn't be worthy of a Pellston workshop, would be those that are regional or country-specific, exploratory in nature, or those that have a lack of international interest.

The Pellston format should be reserved for workshops that will provide an impactful, consequential publication. The intense nature of the workshop results in conclusions being reached. However, although this outcome is enticing, the Pellston Workshop requires a twelve to fifteen month commitment that cannot be taken lightly.

Outside of its pre-existing workshops, SETAC has developed three new types of events. The North American Focused-Topic Meetings, and Special Science Symposiums in Europe, are common in terms of the topics they cover and the outputs that they produce. The purpose of both meetings is to disseminate and exchange current interdisciplinary information on a specific environmental topic.

[26] http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1551-3793.

The third new event type, the Invited Conference, is based on the Gordon Research Conference[27] model and is invitation only. Because the Invited Conferences have less strict publication requirements, the conversations are more open.

9.4 On-Going Effort with the UNEP/SETAC Life Cycle Initiative

SETAC's role within the UNEP/SETAC Life Cycle Initiative has always been to provide substantive scientific expertise as well as the means to deliver this expertise through forums such as the workshops, meetings and symposia described above. Since this role is so significant, it is important that SETAC members continue to be involved in new issues and have the opportunity to join working teams that are addressing new issues. Recently, the organizers of the Initiative identified topics in impact assessment where science is a necessary and high level component.

Although many topics can be tackled by the UNEP/SETAC Life Cycle Initiative, there is still a difference in emphasis on contributions from UNEP, SETAC, or the UNEP/SETAC Life Cycle Initiative. Areas where science still needs to be developed and applied should be major contribution areas by SETAC. For example, it is problematic to address new technologies when there is no existing facility operating to provide actual data within an LCA. How to model new technology that is likely to impact the environment differently than current technology while maintaining comparability and similar uncertainty to datasets from existing well commercialized technologies is a scientific challenge well suited to SETAC member expertise. These emerging or developmental approaches could ultimately be brought into the endorsed set of methods under the Life Cycle Initiative.

9.5 Impact Assessment Advancement

SETAC members have methods and tools that were developed for environmental risk assessment that can be put towards impact assessment advancement. Specifically, SETAC is aligned to be involved in promoting the evolution of a framework and inventory that can support the science of increasing relevant impact assessment methodology. However, not all impact categories are necessarily going to follow the existing LCA methodology. It will be vital for SETAC to bring together a group of impact assessment experts to evaluate the social and environmental impacts that can be measured within LCA. The group would determine what can be done within impact assessment. While some aspects of impact assessment won't be measureable within the logical structure of LCA, some pieces are already capable of being measured in an LCA framework.

[27] http://www.grc.org/.

9.6 Alternative Assessments

SETAC is beginning to expand and alternatively assess materials and chemicals. SETAC's assessment will evolve past toxicological assessment and evaluating risks on the environment and human health to include broader life cycle impacts and life cycle stages. SETAC's unique membership can bring together risk assessment and LCA experts to determine if one chemical or material is more environmentally sound than another.

9.7 LCA in Developing Countries

SETAC's role in LCA development within North America and Europe is much different than its role in developing countries. In areas where LCA is a well-established and practiced tool, SETAC needs to begin to look to specific areas to build and maintain fundamental science as the scope and capability of LCA is expanded and refined. In developing countries, SETAC's role mission for education is more relevant. UNEP uses a formulaic approach to evolving LCA in developing countries (i.e., by gathering local representatives and developing intergovernmental forums). SETAC's role should be to use the LCA community to help develop LCA expertise by hosting learning sessions, webinars and developing education tools for developing countries that are advancing in using LCA. Rather than SETAC's educational focus competing with UNEP/SETAC's structural focus, the two complement each other.

As SETAC is beginning to educate developing countries on LCA, it is important to ask what type of education is relevant. SETAC proposes to develop courses concerning LCA with the aim to bring together local toxicology experts that are able to contribute to local LCA development, what is meant by LCA, why is it important, and what they can do to start building their own internal capacities. This will include a focus on how to create a connection between the regional/local situation and existing LCA frameworks and methods.

Appendix—Glossary

Global Coordinating Group (GCG)	The Global Coordinating Group (GCG) was formed in 2011 as a mechanism for communication between the regional Advisory and Steering Groups in Europe and North America and to allow the other Geographic Units to have representation in global SETAC LCA affairs

International Organization for Standardization (ISO)	After the LCA harmonization by SETAC, shortly after the workshop in Sesimbra in 1993, the LCA ISO standardization process was initiated
LCA in developing countries	SETAC's role should be to use the LCA community to help develop LCA expertise by hosting learning sessions, webinars and developing education tools for developing countries that are advancing in using LCA
LCA in the building sector	LCA can now be used at two levels, at the level of the building as a whole and at the level of building materials or products
Pellston workshops	Pellston Workshops, named after the location of the first workshops (University of Michigan Field Station, Pellston, MI, USA). The goal of a Pellston Workshop is to promote advancement in the resolution of truly cutting-edge technical and policy issues in environmental science, while enhancing strategies of science and philosophy
SETAC LCA groups	The SETAC LCA European group is named 'LCA Steering Committee' The SETAC LCA North American group is named 'LCA Advisory Group'
Technical workshops	SETAC supports the convening of technical workshops to bring together experts to discuss and resolve timely technical, scientific or policy issues related to environmental science. SETAC's level of support can range from simply providing an endorsement (e.g., non-exclusive license to use SETAC name or logo for promotional purposes) to providing full technical and scientific support, as long as basic principles are met
UNEP/SETAC Life Cycle Initiative	In 2002, the United Nations Environment Programme (UNEP), the Society of Environmental Toxicology and Chemistry (SETAC) and partners from governments, academia, civil society, business and industry joined forces to promote life cycle approaches worldwide. This was done to increase resource-efficiency and to accelerate a transition towards more sustainable consumption and production patterns. Sustainable development objectives and a company's bottom line come together in the important topic of assessing and managing the life cycle of processes, materials, products and services
Work groups Life Cycle Impact Assessment	The Life Cycle Impact Assessment workgroup of the LCA Advisory Group of SETAC and that of the LCA Steering Committee of SETAC Europe prepared two individual reports on LCIA. They can be seen as complementary documents. The reports elaborate strong similarities but also a limited number of different positions

	SETAC Europe Report: Towards a Methodology for Life Cycle Impact Assessment. September 1996
	Report of the SETAC Life Cycle Assessment (LCA) Impact Assessment Workgroup, SETAC LCA Advisory Group: Life Cycle Impact Assessment—The State-of-the-Art 1998
Work groups Simplified/Streamlined LCA	In 1994 the LCA Steering Committee of SETAC Europe established the Workgroup Screening and Streamlining. In the same year, the SETAC North America workgroup on Streamlining LCA was initiated. Both groups concluded their multi-year efforts on the issue of Simplifying/Streamlining by a report in each case. The approaches of the reports are different
	SETAC Europe Report: Simplifying LCA: Just a Cut? Final report from the SETAC Europe LCA Screening and Streamlining Working Group. Editor: Kim Christiansen. May 1997
	The report of SETAC Europe discusses the methods for producing simplified procedures, commonly described as screening LCA studies, streamlined LCA studies and simplified LCA studies
	Streamlined Life Cycle Assessment: A Final Report from the SETAC North America Streamlined LCA Workgroup. Edited by: Joel Ann Todd and Mary Ann Curran. July 1999
	The report of SETAC North America is more a description of carefully planning and stating an LCA's goal than it is about Streamlined LCA methodology
Workshop Leiden	'Life-Cycle Assessment—Inventory, Classification, Valuation, Data Bases'. December 2–3, 1991, Leiden, The Netherlands
	It was concluded that the term LCA can best be interpreted as 'life cycle assessment' instead of 'life cycle analysis'
Workshop Sandestin	'A conceptual framework for life cycle impact assessment'. February 1–7, 1992, Sandestin, Florida
	The aim of this workshop was to develop a consensus on the state of the practice and research needs for conducting life cycle impact assessments. The workshop reaffirmed the value of the three-component model for LCAs developed at the Smugglers Notch workshop in 1990. Also, building on the results of the Leiden workshop in 1991, a goal definition and scoping component was incorporated as an additional step
Workshop Sesimbra	'Code of Practice'. Sesimbra, Portugal, March 31 to April 3, 1993

	The European and North American organizations of SETAC planned and conducted the LCA 'Code of Practice' Workshop
	The 'Code of Practice' was intended as guidance for all individuals who commission, carry-out, review, or use the results of an LCA, and should be used to enhance the quality, transparency, and credibility of such studies
	Shortly after this workshop, the LCA ISO standardization process was initiated
Workshop Smugglers Notch	'A technical framework for life cycle assessment'. August 18–23, 1990, Smugglers Notch, Vermont
	The workshop was to develop a framework and consensus on the current state of LCA and research needs for conducting life cycle assessments. Although life cycle assessments have been used, in one form or another, before the name was coined, this workshop report is the first document which presented the name of the method
Workshop Wintergreen	'Data quality: a conceptual framework'. October 4–9, 1992, in Wintergreen, Virginia
	The workshop provided a strong statement that data quality assessment is an integral part of LCA

References

Barnthouse L, Fava JA, Humphreys K, Hunt R, Laibson L, Noesen S, Norris G, Owens J, Todd J, Vigon B, Weitz K, Young J (eds) (1998) Life-cycle impact assessment—the state-of-the-art. Report of the SETAC life-cycle assessment (LCA) impact assessment workgroup, SETAC LCA advisory group. 2nd edn. SETAC Pensacola, FL, USA

Beaufort-Langeveld ASH de, Bretz R, van Hoof G, Hischier M, Jean P, Tanner T, Huijbregts M (eds) (2003) Code of life-cycle inventory practice. (book + CD) ISBN 1-880611-58-9. SETAC Press, Pensacola, FL, USA

Christiansen K (ed) (1997, May) Simplifying LCA—just a cut? Final report from the SETAC Europe LCA Screening and Streamlining Working Group. SETAC Europe. Brussels, Belgium

Consoli F, Allen D, Boustead I, Fava J, Franklin W, Jensen AA, de Oude N, Parrish R, Perriman R, Postlethwaite D, Quay B, Séguin J, Vigon B (eds) (1993) Guidelines for life-cycle assessment: a 'Code of Practice'. Edn 1. From the SETAC workshop held at Sesimbra, Portugal, 31 March–3 April 1993. SETAC Pensacola, FL, USA

de Larderel JA, Fava J (2003) Int J LCA—Associated Journal of the UNEP/SETAC Life Cycle Initiative (Editorial). Int J Life Cycle Assess 8(3):117

Ekvall T (2005) SETAC summaries. J Clean Prod 13(13–14):1351–1358

Fava JA (2002) Life cycle initiative—a joint UNEP/SETAC partnership to advance the life-cycle economy. Int J Life Cycle Assess 7(4):196–198

Fava JA, Denison R, Jones B, Curran MA, Vigon B, Selke S, Barnum J (eds) (1991) SETAC workshop report: a technical framework for life-cycle assessment. August 18–23, 1990, Smugglers Notch, Vermont. SETAC, Washington, DC, USA

Fava J, Consoli FJ, Denison R, Dickson K, Mohin T, Vigon B (eds) (1993, Mar) A conceptual framework for life-cycle impact assessment. Workshop report. SETAC and SETAC foundation for environmental education. Sandestin, Florida, February 1–7, 1992. Published by SETAC and SETAC foundation for environmental education, Pensacola, FL, USA

Fava J, Jensen AA, Lindfors L-G, Pomper S, De Smet B, Warren J, Vigon B (eds) (1994, June) Life-cycle assessment data quality: a conceptual framework. Workshop report. SETAC and SETAC foundation for environmental education. Wintergreen, Virginia, October 1992. Published by SETAC and SETAC foundation for environmental education, Pensacola, FL, USA

Finkbeiner M, Schau EM, Lehmann A, Traverso M (2010) Towards life cycle sustainability assessment. Sustainability 2(10):3309–3322. doi:http://dx.doi.org/10.3390/su2103309

Hunkeler D, Saur K, Rebitzer G, Finkbeiner M, Schmidt WP, Jensen AA, Stranddorf H, Christiansen K (2004) Life-cycle management. ISBN 1-880611-77-5. SETAC Press, Pensacola

Hunt R, Franklin WE (1996) LCA—how it came about. Personal reflections on the origin and the development of LCA in the USA. Int J Life Cycle Assess 1(1):4–7

Klöpffer W (1997) Peer (expert) review in LCA according to SETAC and ISO 14040—theory and practice. Int J Life Cycle Assess 2(4):183–184

Klöpffer W (2003) Life-cycle based methods for sustainable product development. Int J Life Cycle Assess 8(3):157–159

Klöpffer W (2005) The critical review process according to ISO 14040–43. An analysis of the standards and experiences gained in their application. Int J Life Cycle Assess 10(2):98–102

Klöpffer W (2006) The role of SETAC in the development of LCA. Int J Life Cycle Assess 11(Special issue 1):116–122

Klöpffer W (2008) State-of-the-art in life cycle sustainability assessment (LCSA). Life cycle sustainability assessment of products (with comments by Helias A. Udo de Haes, p. 95). Int J Life Cycle Assess 13(2):89–95

Klöpffer W (2012) The critical review of life cycle assessment studies according to ISO 14040 and 14044—origin, purpose and practical performance. Int J Life Cycle Assess 17(9):1087–1093

Kotaji S, Schuurmans A, Edwards S (eds) (2003) Life-cycle assessment in building and construction—a state-of-the-art report. ISBN 1-880611-59-7. SETAC Press, Pensacola

O'Brien M, Doig A, Clift R (1996) 6th SETAC Europe meeting: LCA—selected papers. Social and environmental life cycle assessment (SELCA). Approach and methodological development. Int J Life Cycle Assess 1(4):231–237

Owens JW (1998) Life cycle impact assessment—the use of subjective judgments in classification and characterization. Int J Life Cycle Assess 3(1):43–46

Owens JW (1999) Why life cycle impact assessment is now described as an indicator system. Int J Life Cycle Assess 4(2):81–86

Poulsen PB, Jensen AA, Antonsson A-B, Bengtsson G, Karling M, Schmidt A, Brekke O, Becker J, Verschoor AH (eds) (2004) The working environment in LCA. ISBN 1-880611-68-6. SETAC Press, Pensacola

Rebitzer G, Ekvall T (eds) (2004) Scenarios in life-cycle assessment. ISBN 1-880611-57-0. SETAC Press, Pensacola

Todd JA, Curran MA (eds) (1999, Jul) Streamlined life-cycle assessment—a final report from the SETAC North America streamlined LCA workgroup. SETAC and SETAC foundation for environmental education

Töpfer K (2002) Editorial for Int J LCA on the launch of the UNEP/SETAC Life Cycle Initiative. Int J Life Cycle Assess 7(4):191

Udo de Haes HA (ed) (1996, Sept) Towards a methodology for life cycle impact assessment. ISBN 90-5607-005-3. Published by SETAC Europe, Brussels

Udo de Haes HA, Jensen AA, Klöpffer W, Lindfors L-G (eds) (1994) Integrating impact assessment into LCA proceedings of the LCA symposium held at the fourth SETAC Europe congress, 11–14 April 1994, Brussels. Published by Society of Environmental Toxicology and Chemistry-Europe, Brussels

Udo de Haes HA, Jolliet O, Finnveden G, Hauschild M, Krewitt W, Müller-Wenk R (1999a) Best available practice regarding impact categories and category indicators in life cycle impact assessment. Background document for the second working group on life cycle impact assessment of SETAC Europe (WIA-2, Part 1). Int J Life Cycle Assess 4(2):66–74

Udo de Haes HA, Jolliet O, Finnveden G, Hauschild M, Krewitt W, Müller-Wenk R (1999b) Best available practice regarding impact categories and category indicators in life cycle impact assessment. Background document for the second working group on life cycle impact assessment of SETAC Europe, Part 2. Int J Life Cycle Assess 4(3):167–174

Udo de Haes HA, Finnveden G, Goedkoop M, Hauschild M, Hertwich EG, Hofstetter P, Jolliet O, Klöpffer W, Krewitt W, Lindeijer E, Müller-Wenk R, Olsen SI, Pennington DW, Potting J, Steen B (eds) (2002a) Life-Cycle impact assessment: striving towards best practice. ISBN 1-880611-54-6. SETAC Press, Pensacola

Udo de Haes HA, Jolliet O, Norris G, Saur K (2002b) Life cycle initiative—background, aims and scope. Int J Life Cycle Assess 7(4):192–195

Valdivia S, Ugaya CML, Hildenbrand J, Traverso M, Mazijn B, Sonnemann G (2012) A UNEP/SETAC approach towards a life cycle sustainability assessment—our contribution to Rio+20. Int J Life Cycle Assess 18(9):1673–1685. doi:10.1007/s11367-012-0529-1