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Social Responsibility of Organizations. Directions of Changes ISSN 1899-3192
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LIFE CYCLE MANAGEMENT AS A CRUCIAL ASPECT OF CORPORATE SOCIAL RESPONSIBILITY

Summary: The article presents a general concept of life cycle thinking and life cycle management (considering three dimensions of assessment: LCA, S-LCA and LCC) as well as its compatibility with so-called "triple bottom line" – three pillars of sustainability: environmental, social and economic. In relation to corporate social responsibility and stakeholders relations management, the authors presented 6 RE- philosophy: potential of reduction of resource consumption and improvement of products performance at each life cycle stage. An example of environmental and social responsibility of enterprises is discussed on the basis of the life cycle of bioplastics, especially compostable packaging material made from production waste – Biotrem.

Keywords: life cycle management, corporate social responsibility, sustainable development, biobased materials, Biotrem.

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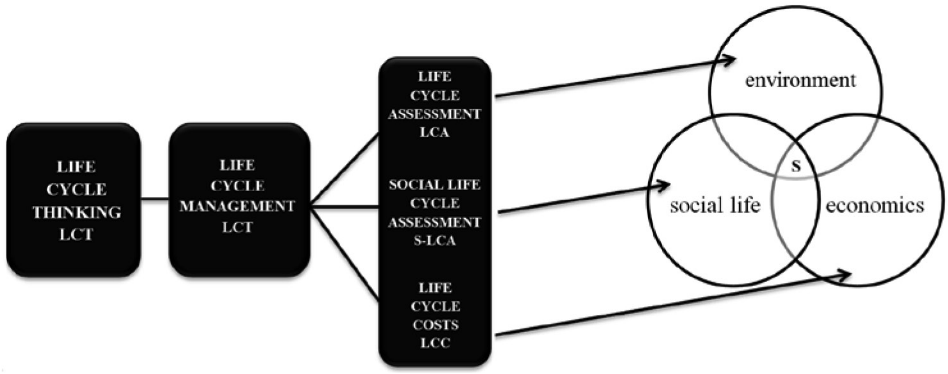
1. Introduction

The concept of a life cycle includes three elements: life cycle thinking, management of a life cycle and practical tools of life cycle assessment: environmental, social and economic. It should be emphasized that this concept is compatible with the so-called "triple bottom line" – three pillars of sustainability: environmental, social and economic (see Figure 1), Life cycle thinking and management as a whole approach can play a significant role in corporate social responsibility of enterprises and in the management of their stakeholders relations.



S – *sustainable development*

Figure 1. Life cycle concept elements in comparison with three pillars of sustainability

Source: own work.

2. From life cycle thinking to CSR through assessment methods and sustainable development

The life cycle thinking (LCT) model provides its users with comprehensive information about environmental, social and economic impacts of products and services. For that reason, it is an important and useful decisions tool. Those features can be used in businesses to demonstrate sustainability and corporate social responsibility, not only on declarative levels [UNEP, SETAC, Life Cycle Initiative 2012a]. Tools and methods connected with the life cycle concept on all the levels – from actual assessment to management systems resulting in sustainability – are presented in Figure 2.

Life cycle thinking is connected with awareness that materials are extracted from nature, converted into process materials, combined with other materials to make product elements, assembled into finished products, shipped to customers who use products and finally disposed in a certain scenario. Along the value chain, energy and other natural, social and economic resources are used; waste is generated, and related impacts, both positive and negative, are distributed across societies to varying degrees around the globe levels [UNEP, SETAC, Life Cycle Initiative 2012a].

Life Cycle concept was originally developed as a way of measuring nuclear power plant environmental impacts. It was then implemented into FMCG markets by Coca-Cola Company [Kuzincow 2013] – life cycle thinking introduced the concept of focusing beyond production facilities. It takes into account environmental, social and economic impacts of a product over its entire life cycle from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, to disposal and/or recycling – in so-called "from cradle to grave perspective levels" [UNEP, SETAC, Life Cycle Initiative 2012a; McDonough, Braungart 2002a].

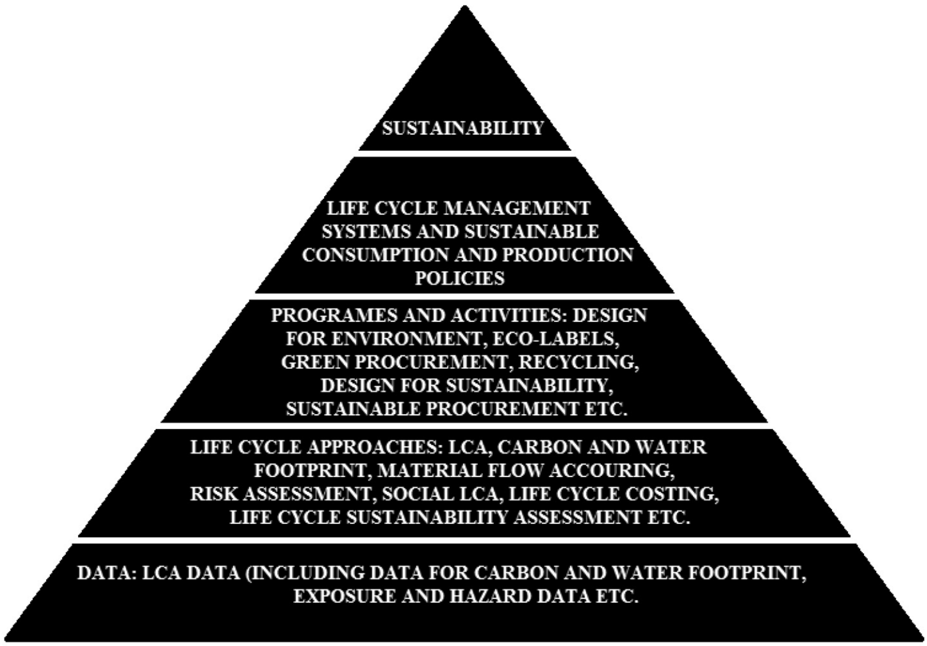


Figure 2. Sustainability framework supported by life cycle thinking and connected approaches

Source: [UNEP, SETAC, Life Cycle Initiative 2012a].

Product life cycle thinking is essential in the path to sustainability by expanding the focus from the production site to the whole product life cycle. This facilitates the links between the economic and environmental dimensions within a company. Life cycle thinking is about widening views and expanding the traditional focus on manufacturing processes to incorporate various aspects associated with a product over its entire life cycle. The producer becomes responsible for products from cradle to grave and can, for example develop products with improved performance in all the phases of the product life cycle.

The main goal of product life cycle thinking is to reduce resource use and emissions to the environment as well as improve the social performance in various stages of a product's life. In this way, companies achieve cleaner products and processes, a competitive advantage in the marketplace, and an improved platform to meet the needs of a changing business climate [UNEP, Life Cycle Initiative 2006].

Life cycle thinking is based on the principles of pollution prevention, where environmental impacts are reduced at the source, and where closed-loop materials and energy is being used. These principles have so far been implemented internally in organizations via cleaner production, environmental management and eco-design programs. LCT expands the general – fashionable, but not always fully ethically implemented and communicated – concept of pollution prevention to include the whole product life cycle and sustainability. Such a way of thinking has been called 6 RE- philosophy (see Figure 3) [UNEP, Life Cycle Initiative 2006].

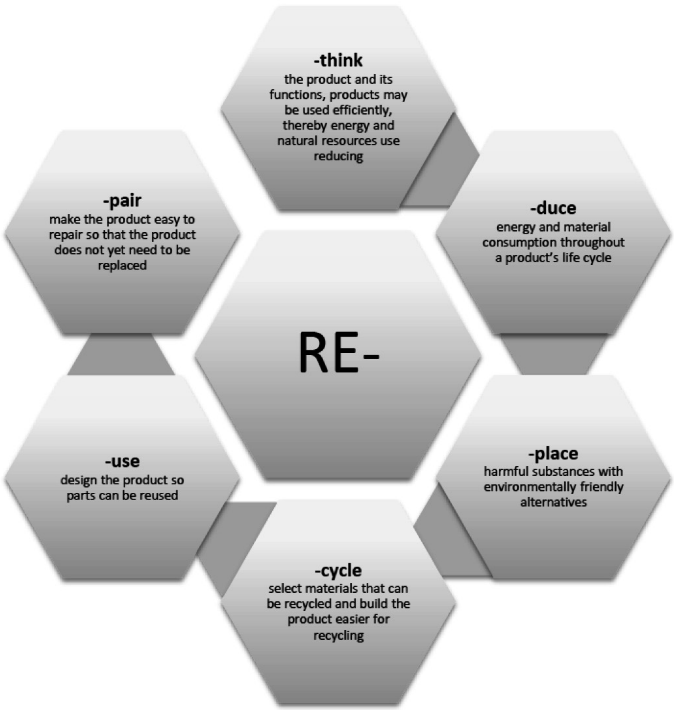
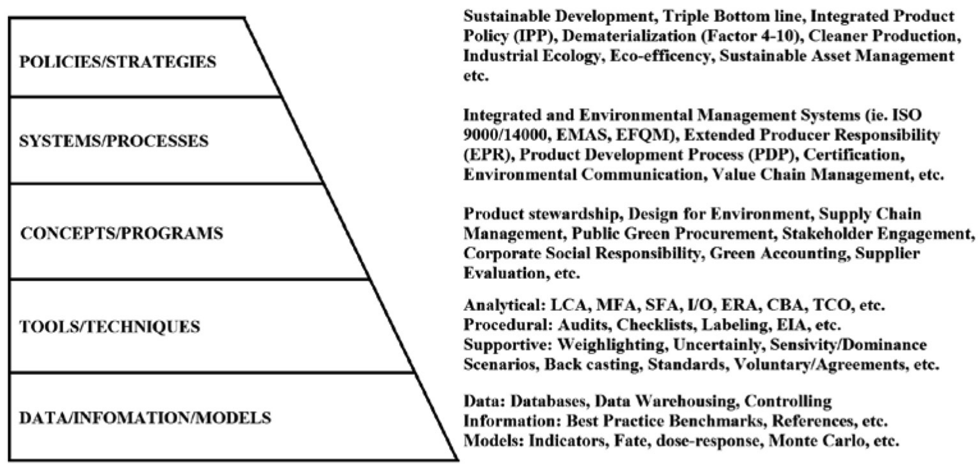


Figure 3. 6 RE- philosophy: potential of resource consumption reduction and improvement of products performance in each life cycle stage

Source: own work based on [UNEP, Life Cycle Initiative 2006].

Entrepreneurs can decide to integrate sustainability and life cycle thinking into everyday management and decision making by using several types of environmental and economic approaches, concepts and tools connected with the life cycle. Obviously, actual companies can also deploy each tool in different ways. The introduction of LCM in a company is a top management decision and has to be in accordance with company policies and strategy. The entry gates of LCM in a company typically corresponds to a function within an organization, such as manufacturing, procurement, marketing, research and development (R&D) or environmental health and safety.

It often happens that a company's department of environment or sustainability initially suggests the implementation of an LCM system. What is especially important in the corporate responsibility context is that interactions with stakeholders (both internal and external) create a basis for the priority setting and provide inspiration for the integration of environmental, social and economic thinking. Figure 4 presents a comprehensive overview of decision levels and policies, systems, concepts, tools and data as a background for a company LCM system [UNEP, Life Cycle Initiative 2006]:



EMAS = environmental management and audit system;
EFQM = European Foundation for Quality Management;
LCA = Life cycle assessment;
MFA = mass flow analysis;
SFA = substance flow analysis; I/O = input-output analysis;
ERA = environmental risk assessment;
CBA = cost-benefit analysis;
LCC = life cycle costing;
TCO = total cost of ownership;
EIA = environmental impact assessment.

Figure 4. All the levels of the life cycle management system that can be implemented in an actual company setting

Source: [UNEP, Life Cycle Initiative 2006].

An operational step of the life cycle scheme – life cycle management – signifies the application of life cycle thinking to actual businesses and real enterprises. It is aimed at managing the total life cycle of products (or in another way, as shown in Figure 5, other elements of activities like processes, general ideas or solutions) and facilitates more sustainable consumption and production. LCM is about systematic integration product sustainability, e.g. in company strategy and planning, product design and development, purchasing decisions and communication programs [UNEP, Life Cycle Initiative 2006].

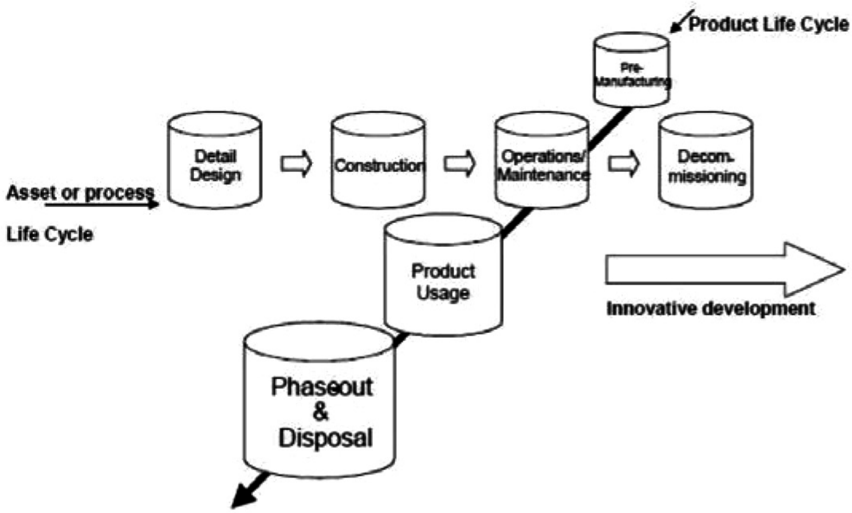


Figure 5. Two dimensions of a life cycle: product and process life cycle lines

Source: [UNEP, Life Cycle Initiative 2006].

2.1. Life cycle assessment

Classic life cycle assessment, called also environmental life cycle assessment (LCA or E-LCA, depending on the source) is a technique that aims at addressing the environmental aspects of a product and their potential environmental impacts throughout the whole life cycle. The term *product* is used here in a marketing meaning and refers to both goods and services. A product's life cycle includes all the stages of a product system, from raw material acquisition or natural resource production to the disposal of a product at the end of its life, including extracting and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling; and final disposal (i.e. cradle-to-grave) [UNEP, SETAC 2009].

The technique was originally developed in the late 1960s and throughout the 1970s to address the desire of enterprises and policy makers to understand the relative environmental impacts of alternative packaging options. The scope of environmental impacts grew with time as more studies were performed for more audiences emerged. Initially, the impacts of interest were limited to energy consumption and the production of solid waste; thus, the inventory data focused on these impacts as well. Emissions of regulated air pollutants were soon added, as were releases of water pollutants [UNEP, SETAC 2009].

LCA implementation standards were developed as part of ISO's standards system of environmental management. Four ISO standards (ISO 14040-14043) were published in 1997–2000, all of which were replaced in 2006 with two standards, ISO 14040 (2006) and ISO 14044 (2006). Those documents – due to the lack of specific standards for social and economic assessment – are also a general basis for all LCM tools.

2.2. Social life cycle assessment

Environmental LCA, itself, does not provide all the information necessary to make intelligent decisions in a sustainability perspective. Social life cycle assessment (or S-LCA) can provide a more comprehensive picture of products impact on the society level, which can be applied on its own or in combination with environmental LCA. It is a social impact (and potential impact) assessment technique, aiming to assess the social and socio-economic aspects of products and their potential positive and negative impacts along normal life cycle including [UNEP, SETAC 2009]:
- raw materials extraction and processing,
- manufacturing,
- distribution,
- use,
- re-use,
- maintenance,
- recycling,
- final disposal.

S-LCA assesses social and socio-economic impacts along the life cycle (supply chain, including the use phase and disposal) using generic and site specific data. It differs from other social impacts assessment techniques by its subject matter: products and services and its scope: the entire life cycle. Social and socioeconomic aspects assessed in S-LCA may directly affect stakeholders positively or negatively during the life cycle of a product. They may be linked to the behaviors of enterprises, to socio-economic processes or have an impact on social capital. Depending on the scope of the study, indirect impacts on stakeholders may also be considered [UNEP, SETAC 2009].

S-LCA neither has a goal nor pretends to provide information on the question of whether a product should be produced or not. S-LCA documents product's utility but neither has the ability nor the function to inform decision-making at that level. It is correct that information on the social conditions of production, use and disposal may provide elements for thoughts on the topic, but will, in itself, seldom be a sufficient basis for a decision [UNEP, SETAC 2009].

Although in theory S-LCA may be conducted on any products, even those somehow knowingly harmful to society, it should be emphasized, in the context of corporate social responsibility and shareholders relations, that it is recommended to use it ethically and it is assumed that peer review will prevent using the methodology inappropriately. For that reason, socially responsible enterprises should provide a list of product categories excluded for ethical reasons. If the product category studied is listed, it is recommended to detail, in the goal and scope phase of the study, the reason why it is ethical and reasonable to conduct a S-LCA of this particular product. Documentation of product's utility and assessment of the use phase should generally reflect the unethical or harmful nature of an actual product [UNEP, SETAC 2009].

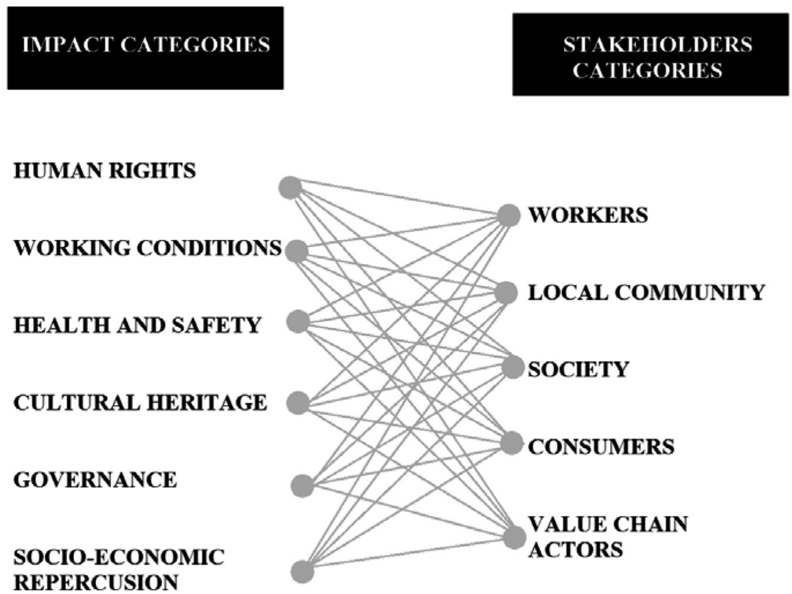


Figure 6. Social life cycle assessment: company stakeholders crossed with impact categories

Source: own source based on [UNEP, SETAC 2009].

S-LCA provides information on social and socio-economic aspects for decision-making, instigating dialogue on the social and socio-economic aspects of production and consumption, in the prospect of improving performance of organizations and ultimately the well-being of stakeholders [UNEP, SETAC 2009]. Stakeholders categories and company impacts that are important when analyzing a life cycle from the social perspective are presented in Figure 6.

2.3. Life cycle costs

The third assessment method related to the life cycle model is connected to widely understood economic dimension. The life cycle costs (LCC) method is a compilation of all the costs related to a product in its whole life cycle – from production through use, maintenance to disposal. Similarly to LCA, it was first developed in the United Stated in the 1960s, but first used by the US military in order to assess the costs of long living goods, like different purpose vehicles. Till now, there have been developed a number of industry guidelines and references according to LCC, but, as previously mentioned, no ISO standard has existed so far [UNEP, SETAC 2009].

Starting point of LCC is the fact that for many objects (material products and services) the purchase price reflects only a minority of the whole costs that will be incurred. It is therefore crucial that cost categories, cost measurement procedures and modeling decisions, such as setting of system boundaries and of possible discount rates, are defined for the LCC. LCC can address the economic impact of a product whose environmental performance is scrutinized in a E-LCA. Since both LCC and classic environmental LCA build on a network of interlinked material flows over the whole life cycle of a product, such a combination is inviting. However, it bears particular modeling pitfalls in order to obtain as good as possible result and consistent assessment, without double counting [UNEP, SETAC 2009].

To ensure this system, boundaries of the environmental LCC need to be equivalent to those from the environmental LCA. They will often not be identical, since research and development, planning and managerial overhead will have decision-relevant costs (and will therefore be considered) even without a significant share of environmental impacts.

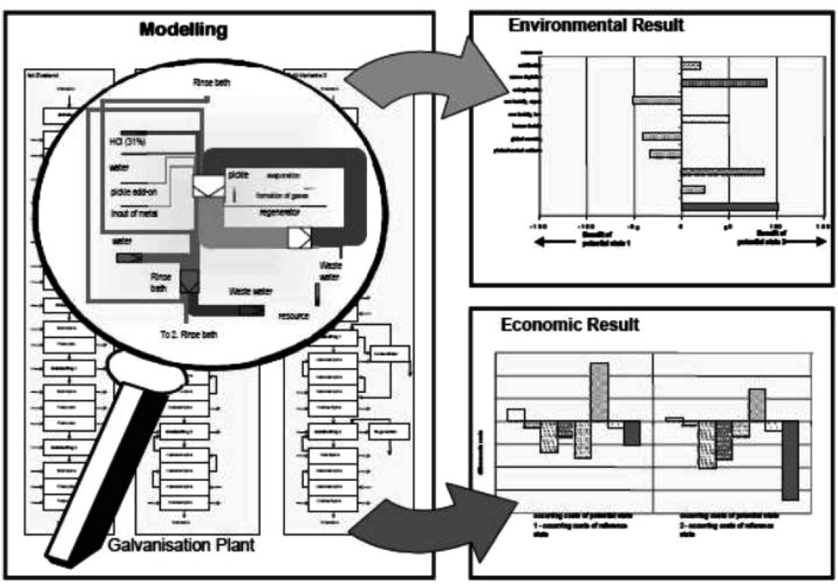


Figure 7. Basic approach in LCM

Source: [UNEP, Life Cycle Initiative 2006].

Because of the general novelty of the two methods: LCC and S-LCA, no formal relations between the two techniques exist [UNEP, SETAC 2009]. This should therefore be the object of further development by United Nations Environmental Program, which created general principles of life cycle thinking, International Organization for Standardization, as well as scientist researching more appropriate tools of CSR and shareholders relations management with quantitative evaluation.

2.4. Life cycle management advantages

An organization can benefit from adopting life cycle management strategy in many ways and in different dimensions. LCM can result in the following benefits presented in Table 1.

Table 1. Corporate benefits of life cycle management strategy

Reputation and image	• Improvement of public image and general relations with stakeholders • Shareholders value increase and steadiness • Green branding of products • Working towards a sustainable business and being at the forefront of competitors
Sustainability	• Sustainable manufacturing processes in all the elements of the business chain • Extended product life time and technological efficiency • Low environmental impacts in the product life cycle (measured by e.g. LCA) • Lowest possible health impacts in the product life cycle • Improvements of occupational safety and health conditions in the whole life cycle • Lowest possible use of non-renewable resources in the whole life cycle • Lowest possible economic costs to consumer and society in the whole life cycle (measured by LCC) • High eco-efficiency (measure of relation between environmental impacts and economic costs) • Design of disassembling and reuse/recycling • Preferable usage of renewable and recycled materials • Preparation for "take back" systems • Best social conditions for workforce (social responsibility) • No child labor
Proactive behavior	• Being prepared for present or future legislative developments, e.g. introduction of integrated product policy and "take back" legislation
Focusing on sustainability and looking beyond the production boundary	• Product stewardship programs • Programs for development and design of new products • Supply chain management, supplier evaluation • Communication in the value chain • Environmental product declarations

	• Corporate social responsibility programs • Marketing activities
Advanced national and international programs	• Being prepared for different eco-labeling schemes (increased visibility, image and sale) • Being ready to join a Dow Jones sustainability index (higher shareholders value) • Being ready for green public procurement programs (increased sales)

Source: [UNEP, Life Cycle Initiative 2006].

2.5. Life cycle management in a socially responsible enterprise

It seems that these days the theoretical basis of corporate social responsibility should be analyzed in two dimensions. First of all, as a scientific question: the very first and still valid four-stages CSR model has been created by well-known theoretician of CSR – Archie B. Carroll. So-called Carroll's pyramid includes subsequent levels of responsibility: from traditional-economic, through legislative, ethical and philanthropic level [Carroll 1979]. Profit should therefore be only a baseline responsibility of an organization, followed by adherence to law, acting in accordance with ethical values and by fulfilling civic duties. A modern approach to Carroll's model was formulated, i.a. by Magdalena Rojek-Nowosielska (see Figure 8) [Rojek-Nowosielska 2011]. According to this kind of interpretation, strictly legal responsibility is required rather by the external environment, but ethical responsibility – even though not codified – is expressly expected by stakeholders.

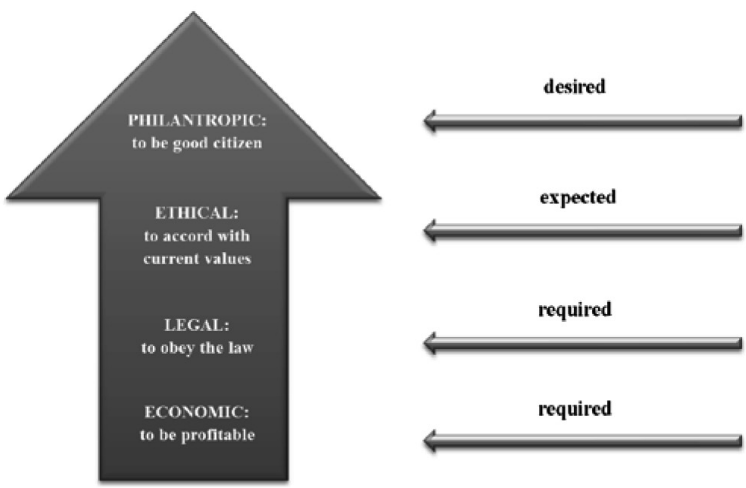


Figure 8. Carroll's model – the modern approach considering social expectations

Source: [Rojek-Nowosielska 2011].

The second, very interesting in this context, dimension is all guidelines concerning the responsibility of business for the impact on external social environment – stakeholders – and natural environment, like *Green Paper: Promoting Framework for Corporate Social Responsibility* of Commission of the European Communities. Its authors see corporate social responsibility as a process that can give the ability to manage relationships with groups of stakeholders having a real impact on their activities. Being socially responsible means not only fulfilling legal expectations, but also going beyond compliance and investing "more" into human capital, the environment and the relations with stakeholders [Commission of the European Communities 2001].

With reference to Rojek-Nowosielska analysis [Rojek-Nowosielska 2011], it should be emphasized that the legal level is required, but very often social expectations and desires go far beyond it. This means that law not always can be a good tool to measure CSR: real corporate social responsibility starts only where the law is obeyed and that is why it is important to demonstrate to stakeholders all the elements of enterprise's activity not covered by the law. And an appropriate way to obtain this is accurate, comparable data expressing and confirming all declaration, provided by scientific research methods like ^{14}C content measurement or life cycle management. Especially the latter, based on the cradle-to-grave perspective and all enterprise's impacts.

3. Life cycle of bioplastics and Biotrem technology

Bioplastics is a whole family of materials which are, according to European Bioplastics Association, biobased, biodegradable or both (see Figure 9). Biobased means that a material or a product is (partly) derived from biomass (plants). Biomass used for bioplastics stems from e.g. corn, sugarcane or cellulose. The term biodegradable refers to a chemical process during which micro-organisms that are available in the environment convert materials into natural substances such as water, carbon dioxide and biomass. The process of biodegradation depends on the surrounding environmental conditions (e.g. location or temperature), on the material itself and on the application [www.europeanbioplastics. com].

In the case of bioplastics their life cycle analysis should focus on the first and last stages: raw materials extraction and reuse and recycling (see Figure 10). As already mentioned, the main goal of product life cycle management is reduction of resources and emissions to the environment. Bioplastics are designed not only to reduce the petrochemical sources consumption, but also to improve environment conditions – as renewable feedstock materials are able to absorb carbon dioxide. At the end of their life, those materials can often be composted, thus becoming a valuable natural resource themselves.

One example of bioplastics is Biotrem, an innovative compostable bran-based packaging material produced from wheat bran, a by-product of milling industry. By utilizing 90%–100% of wheat bran, no depletion of natural resources takes place and it can be considered as an endless resource. Global bran production is estimated at 87 million tons annually and Biotrem expects its maximum demand at 150,000 tons annually. Finally, bran-based packaging reduces the demand for traditional packaging materials [Żakowska, Ganczewski 2011].

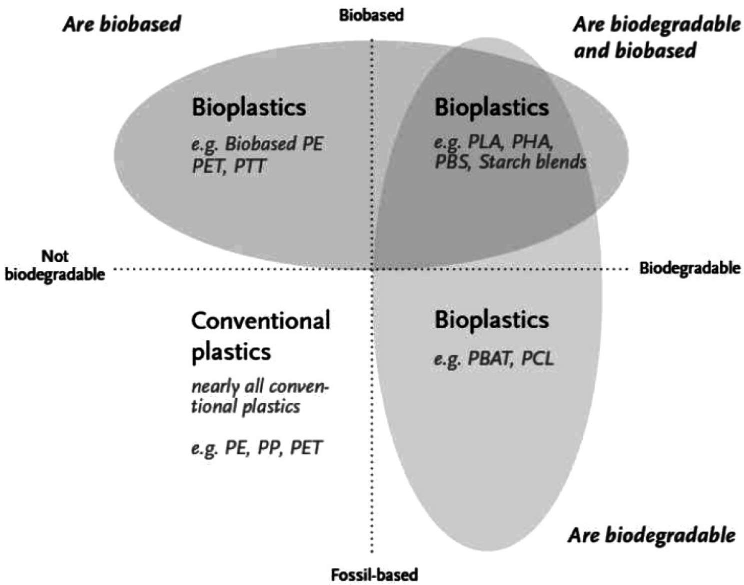


Figure 9. Bioplastics features matrix

Source: [Żakowska 2014].

In addition to this, benefits of Biotrem are visible at all life cycle stages [Żakowska, Ganczewski 2011]:

1. Feedstock:
- bran is plentiful and seasonal economic fluctuation is observed (up to 40% change in price),
- bran steady demand helps in stabilizing prices,
- long term demand will positively affect the milling industry.

2. Production:
- bran based products manufacture will create jobs around mills and rural areas with good infrastructure.
- risk of bran packaging production relocation to cheaper labor countries is small due to increased weight of bran – economically unfeasible.

3. Use:
- unsold food products that are past their due date, can be disposed with their packaging,
- creation of a new sustainable lifestyle.

4. Disposal:
– legal aspects,
– promotion of compostable and biobased packaging.

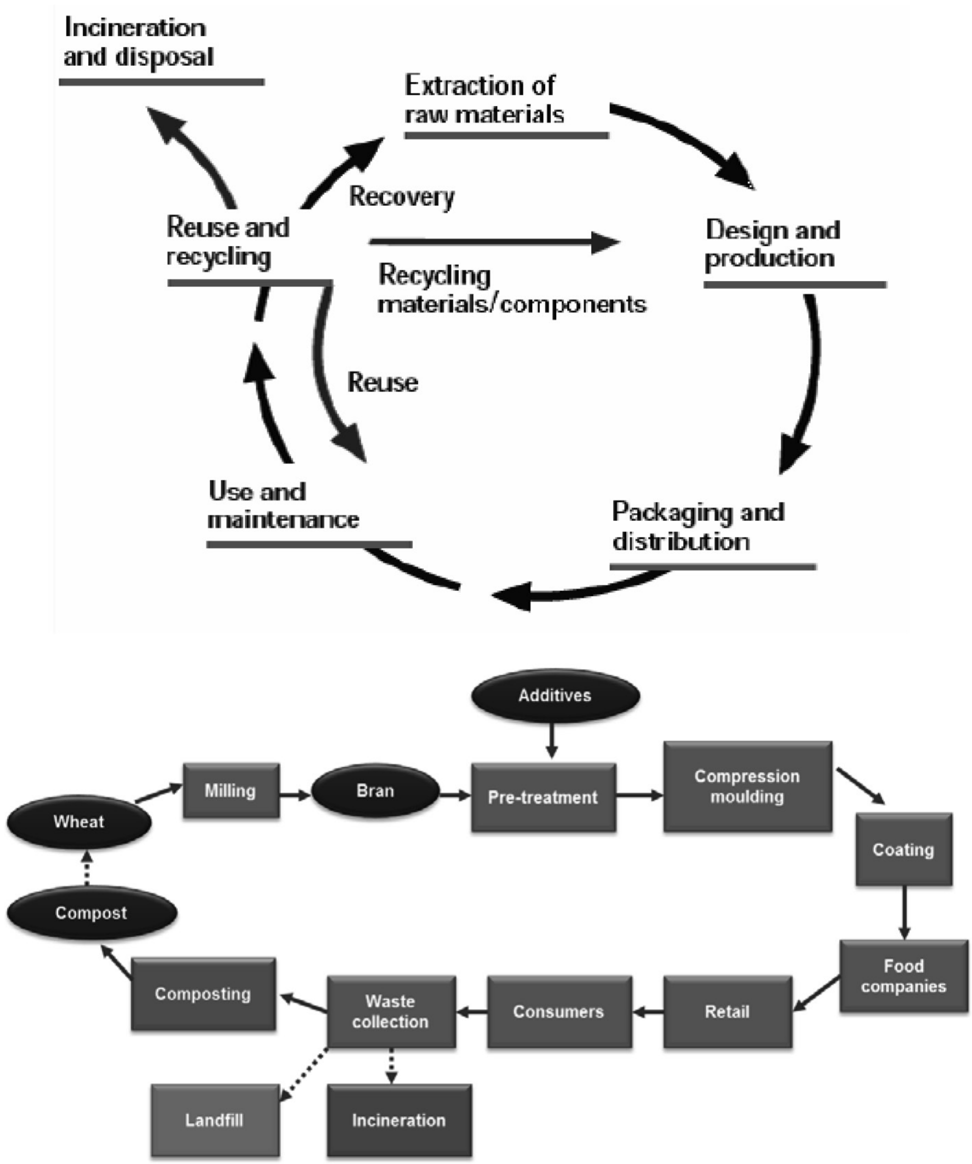


Figure 10. General product life cycle and the life cycle of Biotrem technology

Source: [UNEP, Life Cycle Initiative 2006; Żakowska, Ganczewski 2011].

Biotrem technology is also in line with current trends of packaging production due to its bio-based nature. LCA is very favorable in comparison with other packaging materials and carbon footprint of feedstock material is zero as the carbon used in Biotrem is biogenic. Biotrem is an example of full value chain based in nature [Żakowska, Ganczewski 2011].

The application of bran-based materials is expected to have major beneficial effects on various environmental and social factors. The expected beneficial effects are as follows [Żakowska, Ganczewski 2011]:

- limited depletion of fossil fuels and saving of natural resources, such as forests;
- reduction of greenhouse gas emissions and meeting Kyoto agreement targets;
- reduction of the volume of municipal waste that is disposed via landfill sites or incineration plants and the concomitant pollution;
- reduction of the volume of non-degradable and persistent roadside litter;
- supporting and strengthening of the currently weak financial position of the wheat milling industry and wheat growers.

It is important to clarify some issues related to the acquisition of raw materials. According question of social responsibility, which actually means going beyond legislation, there remain numerous questions regarding entrepreneurs' ethical behavior and so-called "greenwashing" – conscious or unconscious unauthorized communication of non-existent facts. The claims of biodegradability and compostability are widely used by companies as a part of image and competitive advantage building, but claims without quantitative and scientific data cannot be regarded as appropriate. If a material or a product is advertized as biodegradable, further information on the timeframe, the level of biodegradation and the surrounding conditions should be provided [www.european-bioplastics.com].

Moreover, data should be made available to interested parties for verification. For example, substantiation of biobased claims should be based on the ^{14}C content measurement which includes assessment of the overall carbon contained in a material or a product and expresses the biobased carbon content as fraction mass or percent mass [European Bioplastics].

Table 2. Results of the determination of the carbon ^{14}C content for several types of materials

No. of sample	Sample description	Carbon ^{14}C content (AMS) [pMC]
1.	Cellulose film Natureflex	108.33 ± 0.43
2.	Polyethylene film PE-LD	<0.22
3.	Expanded polystyrene EPS	0.27 ± 0.07
4.	Polyolefin film with calcium carbonate	0.82 ± 0.08
5.	**BIOTREM**	**109.65 ± 0.35**
6.	PLA granules 2002D	105.73 ± 0.35

pMC – *percent modern carbon*, modern carbon: pMC > 100

Source: [Żakowska 2014].

For Biotrem such carbon content determination by radiocarbon ^{14}C technique has been carried out as a part of project co-financed by The National Center for Research and Development "Support for research and development on a demonstration scale" at Polish Poznan Radiocarbon Laboratory, using the accelerator mass spectrometry (AMS) technique with the accelerator mass spectrometer. Its results are summarized in Table 2 [Żakowska 2014].

4. Summary

As confirmed by the obtained data shown in Table 2, column 3, samples no. 1, 5 and 6 (cellulose film, Biotrem and PLA granulate), contained organic carbon was assimilated from the atmosphere in the last decades of the 20th century or recent years [Kuzincow, Frydrych, Wróblewski 2014].

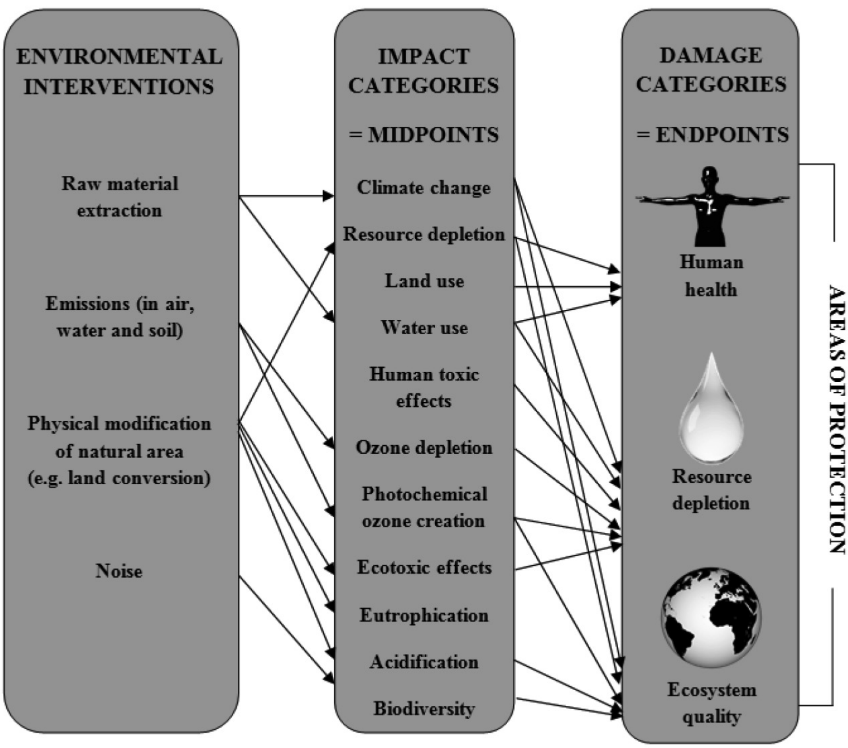


Figure 11. Life cycle assessment mid- and endpoints

Source: [UNEP, SETAC, Life Cycle Initiative 2012b].

It seems that in the case of Biotrem itself two out of three life cycle management dimensions are especially important:

- LCA: environmental assessment in impact categories of land occupation, but also global warming potential, non-renewable energy or mineral extraction (see Figure 11).
- S-LCA: crucial question of using food resources for other purposes than consumption, impact on local community and society in dimension of health and safety and socioeconomic repercussion (see Figure 5).

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LIFE CYCLE MANAGEMENT JAKO ISTOTNY ASPEKT SPOŁECZNEJ ODPOWIEDZIALNOŚCI BIZNESU

Streszczenie: W pracy przestawiono ogólną koncepcję myślenia w kontekście cyklu życia (*life cycle thinking*) i zarządzania cyklem życia (*life cycle management*) w trzech wymiarach oceny: środowiskowym LCA, społecznym S-LCA oraz ekonomicznym LCC. Zaznaczono przy tym zgodność powyższej koncepcji z tzw. *triple bottom line*, schematem uwzględniającym trzy obszary zrównoważonego rozwoju: środowisko naturalne, społeczne i gospodarcze. W nawiązaniu do społecznej odpowiedzialności biznesu oraz zarządzania relacjami z interesariuszami, zaprezentowano także tzw. filozofię 6 RE-, związaną z potencjałem redukcji zużycia zasobów i poprawą wydajności produktów na każdym etapie cyklu życia. Jako przykład praktyk dotyczących ochrony środowiska i społecznej odpowiedzialności przedstawione zostały cykl życia biotworzyw oraz kompostowany materiał opakowaniowy z odpadów produkcyjnych Biotrem.

Słowa kluczowe: zarządzanie cyklem życia, społeczna odpowiedzialność biznesu, zrównoważony rozwój, biotoworzywa, Biotrem.