ISSN 2164-2877 (print)
ISSN 2164-2885 (online)

Life-cycle assessment (LCA) creates new possibilities for entrepreneurs to influence the environmental impact

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ABSTRACT

This paper discusses the Life-cycle Assessment (LCA) and its possibilities for entrepreneurs to influence environmental impact.

LCA is a technique to assess environmental impacts associated with all the stages of a product's entire life from cradle to grave, i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. LCA can help to analyze and compare the environmental impact of products or services via an inventory of energy and material inputs and emissions at all stages. LCAs focus on environmental impacts and originally do not consider social or economic impacts.

The first case study presents the philosophy and thinking model for the LCA technique. Two products, T-shirts, which have been dyed by two different methods: a conventional model and a method based on biotechnology have been compared by Ms. Anne Nielsen and Mr. Per Nielsen at Novozymes A/S.

Another case study by Levi Strauss & Co. presents their outstanding progress innovating around water reduction in denim manufacturing, including creation of the Water<Less™ process and implementing the apparel industry's first Recycle/Reuse standard.

By assessing environmental impact associated with all the stages of a product's life, it makes possible for LCA to create new possibilities for both existing entrepreneurs and for business and engineering students.

Aim of the Paper

The purpose of this study is to examine the Life-cycle Assessment (LCA) and its possibilities for entrepreneurs to influence environmental impact. LCA gives a competitive tool for entrepreneurs to analyze that impact. The core process for LCA investigation is presented in Figure 1. Even the cost burden and marketing issues can be included to the analysis to guide the decision-making.

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ISSN 2164-2877 (print)
ISSN 2164-2885 (online)

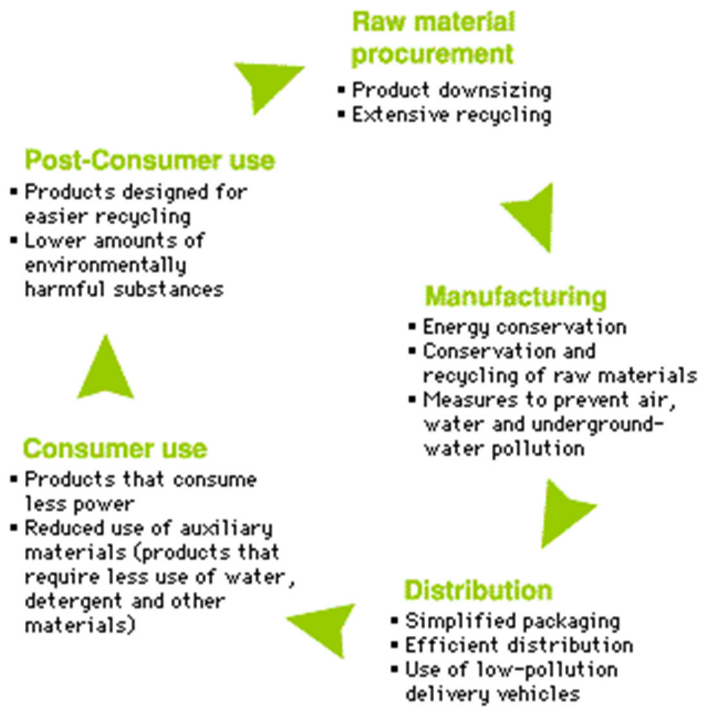

Figure 1. Life cycle assessment process.
Matsushita Graphic Communications Systems, Inc.

Contribution to the Literature

The basic principle of life cycle thinking is that the environmental impacts of a product include not only the environmental impacts of the manufacturing process, i.e. direct impacts, but also all the environmental impacts that a product has at other stages of its life both before and after manufacture, i.e. indirect impacts. The objective is to establish the impacts that result from the manufacture and use of a product. Life cycle thinking has changed people's understanding of environmental impacts and the way in which environmental impacts are studied. It also forms the basis of many national and international sustainable development and environmental policies and has become a widely recognized approach to dealing with environmental issues. In addition to standardized life cycle assessment (International Organization for Standardization, ISO 14040, 2006a), there are several other methods for evaluating environmental impacts that are based on life cycle thinking these days. Simplified footprint calculation tools have been adopted in recent years, which focus on specific environmental impacts or emission classes, such as water, carbon or phosphorus footprints (Finnish Environment Institute SYKE, 2014). Global warming, agricultural land use, eutrophication and use of different chemicals are also often included in reports based on life cycle philosophy (Nielsen & Nielsen, 2009).

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ISSN 2164-2877 (print)
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LCA connects people from business, government, non-profit and international organizations, investors and academics to create a dynamic learning community to escalate change in possibilities for entrepreneurs to influence environmental impact (Water Footprint Network, 2016).

Methodology

The theoretical framework consists of theories dealing with environmental effects assignable to products and services by quantifying all inputs and outputs of material flows and energy and assessing how these material flows and use of energy have an impact of the environment (Cooper & Fava, 2006).

The research approach is qualitative and is based on case studies and expressed by rules in the ISO 14040 (International Organization for Standardization, ISO 14040, 2006).

The first case study presents the philosophy and thinking model for the LCA technique. The case study compares two T-shirt products. The T-shirts have been dyed by two different methods: a conventional model and a method based on biotechnology (Nielsen & Nielsen, 2009).

Another case study by Levi Strauss & Co. presents their outstanding progress innovating around water reduction in denim manufacturing, including creation of the Water<Less™ process and implementing the apparel industry's first Recycle/Reuse standard (Levi Strauss & Co., 2015).

Life Cycle Assessment

What is Life Cycle Assessment?

Life Cycle Assessment (LCA) is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. LCA provides an adequate instrument for environmental decision support. Reliable LCA performance is crucial to achieve a life-cycle economy.

The International Organization for Standardization (ISO), a world-wide federation of national standards bodies, has standardized this framework within the series ISO 14040 (2006) on LCA. ISO 14040/44 are the globally accepted standards for life cycle based environmental assessments. The leading position has been striven to keep as the only globally relevant standard in the field. There is the growing use of ISO 14040/44 inside and outside ISO/TC207, Technical committees, Environmental management in ISO. Much work has been done towards applying, improving, deepening and broadening of the core standards.

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The LCA consists of (see Figure 1).

- Raw material procurement
- Manufacturing
- Distribution
- Consumer use and
- Post-consumer use

Through this process, it is possible to share more information about the environmental impact of the products with both consumers and the factories that make these products — adding a completely new level of transparency. Consumers have more power to shop based on values, while suppliers gain the opportunity to continue collaborating with companies on ongoing improvements in environmental performance.

The Phases of Life Cycle Assessment

Life-cycle assessment has emerged as a valuable decision-support tool for both policy makers and industry in assessing the cradle-to-grave impacts of a product or process. Three forces are driving this evolution. First, government regulations are moving in the direction of "life-cycle accountability;" the notion that a manufacturer is responsible not only for direct production impacts, but also for impacts associated with product inputs, use, transport, and disposal. Second, business is participating in voluntary initiatives, which contain LCA and product stewardship components. These include ISO 14000 and the Chemical Manufacturer Association's Responsible Care Program, both of which seek to foster continuous improvement through better environmental management systems. Third, environmental "preferability" has emerged as a criterion in both consumer markets and government procurement guidelines. Together these developments have placed LCA in a central role as a tool for identifying cradle-to-grave affects both products and the materials from which they are made (International Organization for Standardization, ISO 14040, 2006a).

Four linked components illustrate the various phases of LCA (See Figure 2).

1. Goal and Scope Definition, the product(s) or service(s) to be assessed are defined, a functional basis for comparison is chosen and the required level of detail is defined;
2. Inventory Analysis of extractions and emissions, the energy and raw materials used, and emissions to the atmosphere, water and land, are quantified for each process, then combined in the process flow chart and related to the functional basis;

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ISSN 2164-2877 (print)
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3. Impact Assessment, the effects of the resource use and emissions generated are grouped and quantified into a limited number of impact categories which may then be weighted for importance;
4. Interpretation, the results are reported in the most informative way possible and the need and opportunities to reduce the impact of the product(s) or service(s) on the environment are systematically evaluated. (United Nations Environment, 2009, p. 34)

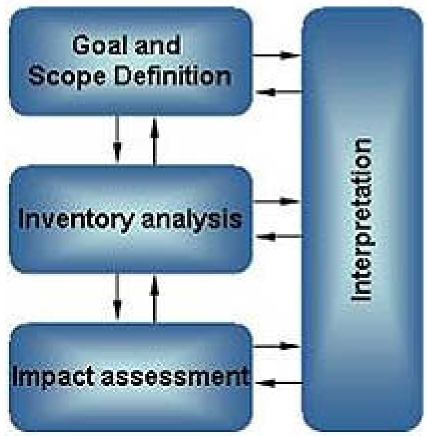

Figure 2. Four linked LCA Components

The calculations of the process are made by using special software. SimaPro is one of the oldest software tools; nowadays, there are many tools specified on a group of products, different materials and different forms of services. Some other tools include GaBi, Umberto, Ide-Mat. More information about the life-cycle assessment can be found at https://en.wikipedia.org/wiki/Life-cycle_assessment.

Case studies

Case Study 1: T-shirts.

Case study 1 presents the philosophy and thinking model for LCA technique. Two products, T-shirts, which have been dyed by two different methods: a conventional model and a method based on biotechnology. Shifting from conventional textile dying and treatment to the new elemental process saves energy and water. The process temperature can be significantly decreased as well as the production time and several baths have been avoided. Furthermore, the applied amounts of some chemicals are reduced.

The magnitude of the savings depends of the way in which the energy is produced and consequently also of the amount of flue gases produced by the process. The savings have an

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ISSN 2164-2877 (print)
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impact on the global warming, acidification, eutrophication and on other impact categories (Nielsen & Nielsen, 2009).

Case Study 2: The lifecycle of a Jean by Levi Strauss & Co.

At Levi Strauss & Co, the focus is to build sustainability into everything they produce. To that end, they conducted the apparel industry's first LCA study in 2007 to assess the full environmental impact of a core set of products from cradle to grave. The study found that the greatest water and energy impact was in two areas: cotton cultivation and consumer use.

Since then, they have made outstanding progress innovating around water reduction in denim manufacturing, including creation of the Water<Less™ process and implementing the apparel industry's first Recycle/Reuse standard.

Levi Strauss & Co. has saved 1 billion liters of water since 2011 through the Water<Less™ process, which reduces the water used in garment finishing by up to 96 percent. They have also taken bold steps to reduce the environmental impact of our products in areas outside their direct control through our Care Tag for Our Planet initiative and by working with the Better Cotton Initiative® (BCI).

In 2015, Levi Strauss & Co. released a new global lifecycle assessment study, an update on the 2007 study that examined the environmental impact of their Levi Strauss & Co. products. The new study analyzed the complete product lifecycle, probing deeper into the environmental impacts of cotton in key growing regions, apparel production and distribution in a range of locations, and consumer washing and drying habits in key markets.

The study shows that of the nearly 3,800 liters of water used throughout the lifetime of a pair of jeans, cotton cultivation (68%) and consumer use (23%) continue to have the most significant impact on water consumption. Consumer care is also responsible for the most significant energy use and climate impact, representing 37 percent of the 33.4 kilograms of carbon dioxide emitted during the lifecycle of a jean.

The new LCA expands on previous research to better understand the impact of cotton cultivation and includes data from the world's primary cotton producing countries, including the United States, China, Brazil, India, Pakistan and Australia. It also analyzes consumer care data from new markets, including China, France and the United Kingdom, to understand the costs and benefits of differences in washing habits (Levi Strauss & Co., 2015).

Findings

The following findings have been discovered in the Novozymes A/S and Levi Strauss & Co. case studies.

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Novozymes process

Novozymes: the LCA analysis indicates that the new process which is called elemental process saves energy and water compared to the conventional process. The process temperature can be significantly decreased as well as the production time and several baths (production steps) have been avoided. Furthermore, the applied amounts of some chemicals are reduced. The environmental load like global warning and acidification as well as eutrophication is remarkably reduced (Nielsen & Nielsen, 2009).

Levi Strauss & Co. General Findings

The general findings, according to Levi Strauss & Co. (2015) address water consumption, climate change, energy consumption, and sustainability. Additionally, consumer use, materials and production, and other issues were included in the case study.

Water Consumption

Fiber production, predominantly cotton, contributes by a wide margin to water consumption. Expanded Scope: By expanding our scope to include the leading cotton-producing countries, we have seen the water consumption from cotton cultivation increase to 68% of the total impact.

Climate Change

Consumer care and fabric production are the most significant phases for climate change impact and energy.

Energy Consumption

Fiber production as well as consumer care influence the energy and water consumption, which in turn influences sustainability.

Sustainability

To handle the waste in a correct way has a big impact on sustainability. To prevent the waste by producing only disposable fabrics for following for example current trends. This provides change of attitude in consumption.

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Consumer use findings

One of the most outstanding findings was that the washing has a big impact on the environment. Washing every 10 times a product is worn instead of every 2 times reduces energy use, climate change impact, and water intake by up to 80%.

The way in which laundry is dried has also a remarkable impact on environment. Cold water and air dry is the most environmentally friendly way.

Materials, production and other findings

Fabric assembly, which includes yarn spinning, dyeing, weaving, and fabric finishing has notable contributions related to climate change impact and non-renewable energy consumption.

Life cycle stages that had minimal contribution to impact include: fabric transport, product transport, packaging, production wastes, distribution, retail, and end of life waste.

Discussion

LCA allows focusing on the most significant environmental impacts as sustainability programs and policies are developed and evaluated. LCA informs product decisions to reduce the environmental impact from design, materials, and manufacturing and supports engagement with external stakeholders to reduce the impact.

Comparative life-cycle analysis is often used to determine a better process or product to use. However, because of aspects like differing system boundaries, different statistical information, different product uses, etc., these studies can easily be swayed in favor of one product or process over another in one study and the opposite in another study based on varying parameters and different available data. There are guidelines to help reduce such conflicts in results but the method still provides a lot of room for the researcher to decide what is important, how the product is typically manufactured, and how it is typically used.

A criticism of LCA is that it attempts to eliminate monetary cost analysis, which is replacing the currency by which economic decisions are made with an energy currency. It has also been argued that energy efficiency is only one consideration in deciding which alternative process to employ. However, LCA does help companies become more familiar with environmental properties and improve their environmental system.

In recent years, the literature on LCA of energy technology has begun to reflect the interactions between the current electrical grid and future energy technology. Some papers have focused on energy life cycle, while others have focused on carbon dioxide (CO_2) and other greenhouse

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ISSN 2164-2877 (print)
ISSN 2164-2885 (online)

gases. The essential critique given by these sources is that when considering energy technology, the growing nature of the power grid must be taken into consideration. If this is not done, a given class of energy technology may emit more CO_2 over its lifetime than it mitigates.

Conclusions

LCA can create **new possibilities** for both existing entrepreneurs and for business and engineering students. LCA is a **competitive tool** for entrepreneurs to analyze both the environmental impact and even the cost burden and marketing issues to guide the decision-making. Start-up entrepreneurs in the LCA field can act as **consultants** for the whole business life to assist in understanding these environmental impacts. When focusing on LCA field **engineering students** could also concentrate on main subjects when selecting their curriculum alternatives.

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