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LIFE CYCLE ENGINEERING

“WHERE SCIENCE STOPS IS ACTUALLY ALSO WHERE SCIENCE BEGINS TO GET INTERESTING.”

JUSTUS VON LIEBIG (1803 – 1873), GERMAN CHEMIST

LIFE CYCLE ENGINEERING

The Life Cycle Engineering Department was established in 1989 at the Institute for Polymer Testing and Polymer Science (IKP) at Universität Stuttgart. In 2006 it changed to the Chair for Building Physics (LBP) at Universität Stuttgart, and thereafter, beginning in 2008 at the Fraunhofer Institute for Building Physics IBP. The department's key research area is life cycle engineering and analyses of products, processes and services in terms of their ecological, economic, technical and social aspects, providing a basis for decision-making throughout the entire life cycle.

MAIN AREAS OF RESEARCH

- Life Cycle Engineering (LCE)
- Life Cycle Assessment (LCA)
- Life Cycle Costing (LCC)
- Social Aspects – Life Cycle Working Environment (LCWE)
- Sustainability Assessment
- Design for Environment (DfE)
- Environmental Product Declarations (EPD)
- Material Flow Analysis (MFA)

The focus of research in the Life Cycle Engineering department is upon methods in sustainability assessment. Working together with partners from the areas of policy-making, industry and research institutions, specific projects with a pronounced international orientation pursue life-cycle-related topics involving overriding questions in the areas of technical feasibility, capacities, infrastructure and materials management. To make the daily work of sustainability assessment easier, a practice-oriented software and database system, called "GaBi", is being developed in cooperation with partner firm PE INTERNATIONAL. At a reasonable cost, users can set up system models – even complex models – and evaluate them under various criteria, such as environmental impacts or the life cycle costs of a product system.

The Life Cycle Engineering method has been and currently is applied in a multitude of projects in the department. Customers include industrial firms and public-sector clients.

The existing expertise is passed along in lectures for students in technical disciplines. The engineering background, extensive project experience and the successful combination of research and practical industrial applications all lead to high-quality, reliable and customer-oriented solutions. The tools and databases developed along the way are in use in all sectors of industry worldwide, as well as in research and consulting in sustainability assessment.

LIFE CYCLE ENGINEERING (LCE)

Life Cycle Engineering (LCE) is an approach that analyzes the potential ecological, economic, technical and social impacts of products, processes and services throughout an entire life cycle. This multi-dimensional view ensures that all of the important factors are assessed within the framework of decision-making with an interest in sustainability. The Life Cycle Engineering methodology presents the results clearly, guaranteeing maximum transparency along with a solid basis for decision-makers.

To map the ecological, economic, technical and social impact of a product, process or service, Life Cycle Engineering combines an array of methods that will be discussed below.

LIFE CYCLE ASSESSMENT (LCA)

Life Cycle Assessment (LCA) refers to a systematic analysis of the environmental impact of products, processes or services along the entire life cycle involved ("from cradle to grave", so to speak). This includes all environmental impacts arising during production, the usage phase, and disposal. It also includes all processes associated with the production system, i.e. all upstream and downstream processes (e.g. production of the raw materials, auxiliary materials and supplies). The Life Cycle Assessment method can be enlisted as a tool for environment-oriented decision-making. It is used to develop and improve products. The method is also applied within the strategic-planning framework, in political decision-making processes and in the area of marketing. The Life Cycle Assessment is a subcomponent of Life Cycle Engineering and is standardized under ISO 14040/44.

The basic procedure followed for a Life Cycle Assessment can be described as follows:

- The material and energy flows for an entire product system – meaning all of the processes involved – are analyzed along that product's entire life cycle.
- Emissions to the air, water and ground, along with the resources taken from nature, are systematically recorded and entered in a "Life Cycle Inventory".
- The potential environmental impacts, such as the global warming, summer smog, acidification, eutrophication, etc., are then analyzed as part of a "Life Cycle Impact Assessment".

A Life Cycle Assessment is broken down into four steps (ISO 14040/44):

1. **Definition of the goal and scope**
   The first step of a Life Cycle Assessment specifies the objective(s) and the framework of the investigation. This includes, for instance, definition of the system boundaries, of the functional unit of the system, and of requirements in terms of data quality.
2. **Life Cycle Inventory (LCI)**
   The Life Cycle Inventory contains the data collection for all required input (resources) materials and output (emissions, waste) materials including also energy flows recorded in an inventory.

3. **Life Cycle Impact Assessment (LCIA)**
   With the aid of the findings of the Life Cycle Inventory, the Life Cycle Impact Assessment uses appropriate characterization models in a software-assisted procedure to calculate the potential environmental impacts, along with effects on human health and resource availability.
4. **Results and Interpretation**
   In accordance to the goal of the LCA study the calculated LCI and LCIA results will be interpreted and recommendations for decision-making given.

LIFE CYCLE COSTING (LCC)

Sustainable action requires consideration not only of ecological criteria but also particularly of economic aspects in process and product developments, comparison of alternatives, etc. Life Cycle Costing is an useful aid to decision-making under conditions of sustainability. It presents an occasion to analyze economic aspects under the same system boundaries and framework conditions as the environmental Life Cycle Assessment. In this case, the life cycle is defined based on an outlook similar to that applicable to the Life Cycle Assessment.

The Life Cycle Costing method permits an accounting of all of the costs associated with a product or service. All of these costs are entered and analyzed in a structured way across the entire life cycle. The results of an LCC analysis are particularly useful for

– assessing various options: an LCC analysis identifies the overall costs across the life cycle of a product or service. This permits analysis and comparison of competing options;
– improved knowledge about the economic life cycle: application of the LCC method provides management with a more complete and more accurate picture of the cost drivers within a particular process, such as the role of material and energy costs. Investigations of cost drivers can also provide managers with information about areas in which action is needed;
– support in decision-making: with the LCC method, total investment costs can be evaluated even at an early stage in a product's development.

SOCIAL ASPECTS

"Sustainability" is an expression used increasingly to promote products. Behind the expression is a sustainable approach that takes ecological, economic and social aspects into account. The approaches we see today frequently neglect the social aspects involved in a particular course of action. The difficulty involved in considering social aspects is to cast social information in terms of the processes involved – processes that are aggregated along the value-added chain and can be managed in databases. These processes are fundamental to an integrated approach to social aspects within the framework of analyses of life cycles. One solution in this regard is the Life Cycle Working Environment

(LCWE), a solution developed in the Life Cycle Engineering Department. Data about working conditions are integrated into the LCA at the process level. The method covers the following fields:

– Amount and qualification level of work
– Health and safety information
– Information on acceptance of ILO (International Labour Organization) humanitarian conventions

Since this approach links statistical data with process data, it offers better data quality than social data based on input/output matrices. A catalog of criteria ensures that the method is applicable and comparable worldwide. The catalog also guarantees alignment with the LCA methodology and conventional applications.

DECISION-MAKING SUPPORT FOR POLICYMAKERS AND INDUSTRY

The benefits of Life Cycle Engineering and the methods it entails lies in the aid it provides to decision-making in the fields of industry and environmental policy from the standpoint of sustainability, particularly in the following areas:

– Improvements in ecological and economic performance
– Prevention of shifting burdens to other phases of the life cycle
– Comparison and optimization of different design alternatives from a sustainability point of view
– Analysis of a product life cycle during its development, permitting early stage identification and prevention of environmental weakpoints
– Enhanced energy and resource efficiency
– Reduction of strategic business risks
– Supporting of marketing purposes
– Support in fulfilling legal requirements

ENVIRONMENTAL PRODUCT DECLARATIONS (EPD) FOR BUILDING PRODUCTS

Emissions levels, life cycle costs, and energy efficiency – these are just a few of the requirements a sustainable building must fulfill today. The building materials and building products used in a building play a crucial role in environmental impact. A relevant assessment of the environmental performance of building products can only be provided against the backdrop of a building concept and building use. Determinative in this regard are

– the planning and design of the building,
– the structural and technical concept,
– the building quality achieved, along with the building products used.

Building products are not simply either “good” or “bad”. From a technical, visual and ecological standpoint, their performance must always be seen in the context of an overall system. Decisive is suitable use of the products within the building itself.

The Environmental Product Declaration: verified and reliable information in a convenient format

Environmental Product Declarations (EPD), also known as “Type III environmental declarations” under ISO 14025, offer the information on which a Life Cycle Assessment can be based; this is why they are required for the sustainability certification of buildings.

The European Commission views EPDs as the appropriate means of communicating the environmental performance of building products while promoting sustainable construction generally. In the CEN Technical Committee TC 350, standard EN 15804 relating to rules for product categories was compiled and published in 2012.

What does an EPD contain?

EPDs contain information about the life cycle of a building product, Life Cycle Engineering parameters and test results for a detailed assessment, e.g. indoor emissions of volatile organic compounds (VOC).

Environmental Product Declarations for building products

– have a binding, general foundation,
– are drawn up by experts (e.g. the Life Cycle Engineering Department) and manufacturers,

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- are independently verified,
- remain the manufacturer's responsibility,
- form the basis for sustainable building.

What are the benefits of EPDs?
An EPD provides credible and comparable information about the environmental performance of products.

- Makers of building products use EPDs to provide information about their products and use this information for marketing purposes. Companies that manufacture building products use EPDs to foster a prospective approach to management and as an instrument of control within the company.
- Architects and planners use EPDs as a basis for generating a building's Life Cycle Assessment. This is a prerequisite for sustainability certification of buildings. Environmental aspects are considered alongside criteria such as technical performance, costs, acceptance and aesthetics.
- EPDs are a feature of calls for bids. They serve to guide and verify adherence to environmental specifications in construction planning.
- Real estate firms and developers assign a higher value to their investments and properties. Properties can be marketed better if designed and certified as sustainable buildings.
- Retailers and end consumers use EPDs as a verified source of environmentally relevant product information.

Sharing information with EPDs
You can find sample EPDs at: www.bau-umwelt.de. The German declaration system for EPDs of building products is organized by the Institute for Construction and the Environment (Institut Bauen und Umwelt e.V. [IBU, formerly AUB]). The IBU is an initiative launched by manufacturers of construction products who have committed themselves to sustainable building.

SAMPLE PROJECTS

- Biodiversity Evaluation of effects of product systems [BfN/BMU]
- CILECCTA – A user-oriented, knowledge-based suite of Construction Industry LifE Cycle CosT Analysis software for pan-European determination and costing of sustainable project options [EU FP7]
- Comparative LCA study of fossil and biofuels [Petróleo Brasileiro S.A. – Petrobras]
- Eco-Design for Airframe (EDA) / Technology Evaluator (TE) [Clean Sky JU]
- EeBGuide – "Operational guidance for Life Cycle Assessment studies of the Energy efficient Buildings Initiative" [EU FP7-EeB]
- Fraunhofer Research for the Future – Markets Beyond Tomorrow: "Molecular Sorting for Resource Efficiency"
- FSEM – Fraunhofer System Research on Electric-Powered Mobility, Project 4: "Technical System Integration, Socio-Political Topics and Project Management", WP4 "Life Cycle Assessment of Concepts for Electric-Powered Mobility" [BMBF]
- HyTEC – Hydrogen Transport in European Cities [FCH JU]
- Land Use Impact Assessment of Forestry Processes Methodology Development [SCA, TetraPak]
- Morgenstadt: City Insights – Innovation Network of 12 Fraunhofer Institutes with partners from the industry and municipalities
- PUMA Sustainability Strategy for Retail Stores [PUMA RETAIL AG]
- Waste2Go – Development and verification of an innovative full life sustainable approach to the valorisation of municipal solid waste into industrial feedstocks [EU FP7]
- Scientific monitoring of planning and constructing the SWU GmbH building within the framework of the project "Bebauung Karlstraße" [SWU GmbH]

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