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Buildings life cycle – Assessment

Števo Stano · Elektrotechnika, Informačné technológie, Strojárstvo

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Ecological building design has become an important international trend over the last ten years. Buildings consume 70% of our production of electricity and produce 65% of our waste. At the same time are using 12% of our water and contribute to a production approximately 30% of all greenhouse gas emissions. More than any other service or industry, construction industry and operation of buildings can contribute to better control of scarce resources and reduce greenhouse gas emissions (mainly CO_2).

Ecological, economical, „green“?

We can often see label as organic, efficient, or green. It is a marketing tool or a true indication of reduced product impact (product, technology or construction) to the environment? We will try to bring you the example of the biomass boiler, which is nowadays seen as a "green" often referred to as a source of "low or zero CO_2 production". Common market biomass boiler definition is:

"Biomass boilers run on organic fuels such as wood pellets and count as zero-emission because the amount of carbon dioxide they give off when they are burned is offset by the amount that was absorbed when the crop was grown."

Reality or fiction?

The manufacturing process includes many steps as raw material gathering, sorting, drying materials, pelletizing, pellet cooling, storage, packaging and import of pellets. Each of these processes requires the use of certain equipment and energy (materials gathering – truck transport, drying materials – need to about 5 MJ per 1 kg of evaporated water [1], pelletising – chipper, pelletizing machine, etc.). Each process produces CO_2 in a certain way therefore:

"The amount of carbon dioxide they give off when they are burned is offset by the amount that was absorbed when the crop was grown"

This sentence is very misleading in terms of overall production of carbon dioxide.

Ecological, green – economical building

If we want to assess the energy performance of buildings and its impact on the environment, we must analyze the entire building life cycle (from production of materials to the building demolition and recycling) and not only from the using time of the building. Each element, the system structure must be made. This production is made using a technology and tools, which consumes energy and materials. Tools must also be produced using other technologies, which again consume some energy and materials.

Materials resulting from the processing of raw materials that are extracted from nature and using the energy of certain tools/technology etc, we could go on forever. Such analysis may reveal the fact that the production technology itself can consume more energy than the potential savings that the technology offers. This analysis is called "life cycle assessment" (LCA)[2]

Life Cycle Assessment

A life-cycle assessment (LCA, also known as life-cycle analysis, eco-balance, and cradle-to-grave analysis)[3] is a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).

Goals and purpose

The goal of LCA is to compare the full range of environmental effects assignable to products and services in order to improve processes, support policy and provide a sound basis for informed decisions. The term life cycle refers to the notion that a fair, holistic assessment requires the assessment of raw-material production, manufacture, distribution, use and disposal including all intervening transportation steps necessary or caused by the product's existence.

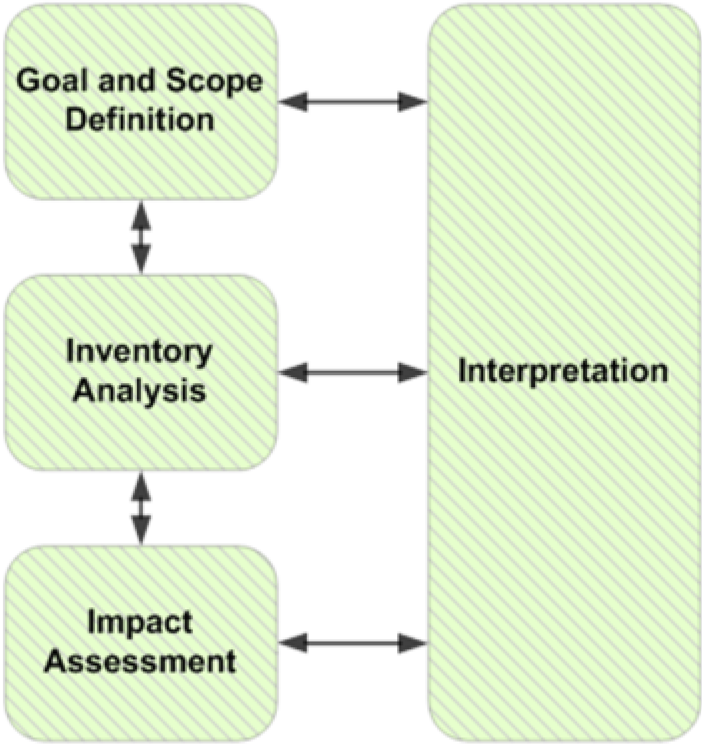
Attribution and consequential LCA

There are two main types of LCA. Attribution LCAs seek to establish the burdens associated with the production and use of a product, or with a specific service or process, at a point in time, typically the recent past. Consequential LCAs seek to identify the environmental consequences of a decision or a proposed change in a system under study, typically oriented to the future. This entire means that market and economic implications of a decision may have to be taken into account. Social LCA is under development as a different approach to life cycle thinking intended to assess social implications or potential impacts. Social LCA should be considered as an approach that is complementary to environmental LCA.

The procedures of life cycle assessment (LCA) are part of the ISO 14000 environmental management standards: in ISO 14040:2006 and 14044:2006. (ISO 14044 replaced earlier versions of ISO 14041 to ISO 14043.)

Four main phases

According to the ISO 14040 and 14044 standards, a Life Cycle Assessment is carried out in four distinct phases as illustrated in the figure shown to the right. The phases are often interdependent in that the results of one phase will inform how other phases are completed.



Goal and scope

An LCA starts with an explicit statement of the goal and scope of the study, which sets out the context of the study and explains how and to whom the results are to be communicated. This is a key step and the ISO standards require that the goal and scope of an LCA be clearly defined and consistent with the intended application.

Data analysis

A life cycle analysis is only as valid as its data; therefore, it is crucial that data used for the completion of a life cycle analysis is accurate and current. There are two basic types of LCA data – unit process data and environmental input-output data (EIO), where the latter is based on national economic input-output data. [4] Unit process data is derived from direct surveys of companies/plants producing the product of interest and is carried out at a unit process level that is defined by the system boundaries for the study.

Data validity is an ongoing concern for life cycle analyses. Due to globalization and the rapid pace of research and development, new materials and manufacturing methods are continually being introduced to the market. This makes it both very important and very difficult to use up-to-date information when performing an LCA. If an LCA's conclusions are to be valid, the data must be recent; however, the data-gathering process takes time.

Using 5 to 10 years old data, LCA may not be accurate because the quantitative analysis does not reflect the current practices used in the process or product. Therefore, the conclusions will be drawn from a report by the data inconclusive. Some products, processes which do not change between 5 to 10 years (if any) shall be exempt from the necessity of obtaining the actual data.

LCA variants

Cradle-to-grave

Cradle-to-grave is the full Life Cycle Assessment from resource extraction (‘cradle’) to use phase and disposal phase (‘grave’). For example, trees produce paper, which can be recycled into low-energy production cellulose (fiberised paper) insulation, then used as an energy-saving device in the ceiling of a home for 40 years, saving 2,000 times the fossil-fuel energy used in its production. After 40 years the cellulose fibers are replaced and the old fibers are disposed of, possibly incinerated. All inputs and outputs are considered for all the phases of the life cycle.

Cradle-to-gate

Cradle-to-gate is an assessment of a partial product life cycle from resource extraction (‘cradle’) to the factory gate (i.e., before it is transported to the consumer). The use phase and disposal phase of the product are omitted in this case. Cradle-to-gate assessments are sometimes the basis for environmental product declarations (EPD) termed business-to-business EDPs. [5]

Cradle-to-Cradle or Open Loop Production

Cradle-to-cradle is a specific kind of cradle-to-grave assessment, where the end-of-life disposal step for the product is a recycling process. It is a method used to minimize the environmental impact of products by employing sustainable production, operation, and disposal practices and aims to incorporate social responsibility into product development. [6] From the recycling process originate new, identical products (e.g., asphalt pavement from discarded asphalt pavement, glass bottles from collected glass bottles), or different products (e.g., glass wool insulation from collected glass bottles).

Gate-to-gate

Gate-to-gate is a partial LCA looking at only one value-added process in the entire production chain. Gate-to-gate modules may also later be linked in their appropriate production chain to form a complete cradle-to-gate evaluation. [7]

Well-to-wheel

Well-to-wheel is the specific LCA used for transport fuels and vehicles. The analysis is often broken down into stages entitled “well-to-station”, or “well-to-tank”, and “station-to-wheel” or “tank-to-wheel”, or “plug-to-wheel”. The first stage, which incorporates the feedstock or fuel production and processing and fuel delivery or energy transmission, and is called the “upstream” stage, while the stage that deals with vehicle operation itself is sometimes called the “downstream” stage. The well-t--wheel analysis is commonly used to assess total energy consumption, or energy conversion efficiency and emissions impact of marine vessels, aircrafts and motor vehicle emissions, including their carbon footprint, and the fuels used in each of these transport modes. [8][9]

Life cycle energy analysis

Life cycle energy analysis (LCEA) is an approach in which all energy inputs to a product are accounted for, not only direct energy inputs during manufacture, but also all energy inputs needed to produce components, materials and services needed for the manufacturing process. An earlier term for the approach was energy analysis. With LCEA, the total life cycle energy input is established.

Energy production

It is recognized that much energy is lost in the production of energy commodities themselves, such as nuclear energy, photovoltaic electricity or high-quality petroleum products. Net energy content is the energy content of the product minus energy input used during extraction and conversion, directly or indirectly. A controversial early result of LCEA claimed that manufacturing solar cells requires more energy than can be recovered in using the solar cell. The result was refuted, but the use of solar cells is still controversial. [10] Another new concept that flows from life cycle assessments is Energy Cannibalism. Energy Cannibalism refers to an effect where rapid growth of an entire energy-intensive industry creates a need for energy that uses (or cannibalizes) the energy of existing power plants. Thus during rapid growth the industry as a whole produces no energy because new energy is used to fuel the embodied energy of future power plants.

Advantages of using the LCA

LCA Helps to Avoid Shifting Environmental Problems from One Place to Another

An LCA allows a decision maker to study an entire product system hence avoiding the sub-optimization that could result if only a single process were the focus of the study. For example, when selecting between two rival products, it may appear that Option 1 is better for the environment because it generates less solid waste than Option 2. However, after performing an LCA it might be determined that the first option actually creates larger cradle-to-grave environmental impacts when measured across all three media (air, water, land) (e.g., it may cause more chemical emissions during the manufacturing stage). Therefore, the second product (that produces solid waste) may be viewed as producing less cradle-to-grave environmental harm or impact than the first technology because of its lower chemical emissions.

An LCA can help decision-makers select the product or process that results in the least impact to the environment. This information can be used with other factors, such as cost and performance data to select a product or process. LCA data identifies the transfer of environmental impacts from one media to another (e.g., eliminating air emissions by creating a wastewater effluent instead) and/or from one life cycle stage to another (e.g., from use and reuse of the product to the raw material acquisition phase).

Life cycle assessment of buildings

According to mentioned principles of life cycle assessment, it is clear that house, which at first sight appear as ecological (for example, is the energy class A) may have just a worse environmental impact than a house in lower energy categories. Similarly, it would seem nonsensical term “electric green”, which should be zero fossil fuel consumption, but its production, development and recharge the batteries would consume more fossil fuel than traditional automobile traffic. (70% of the world’s electricity is produced from fossil fuels, thus recharging electric indirect means of consumption of fossil fuels).

When we analyze buildings of our grandparents (eg Orava timber) by the LCA, whether in terms of CO2 emissions or energy requirements, we find that often today’s “zero” or “green” buildings have a much worse impact on the environment. Nowadays the designation “eco” (assigned without any LCA) appears in many cases purely as a marketing tool. To determination of the buildings impact on the environment is important to carefully consider the entire lifecycle of the building. From an architectural concept, through the materials to the individual technologies that will the building use. Above each solution are always a man and his needs, which ultimately determine the consumption and use of natural resources (affect the building impact on the environment).

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