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Zero House? Reality or fiction

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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 they are using 12% of our water and contribute to a production of 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).

House with zero-carbon production

In order to minimize the impact of buildings on the environment British Research Establishment (BRE) has developed house with a “zero carbon production”, which was built in Watford (England). The heart of the concept for the Lighthouse is the ambition to create homes where the innovative environmental systems and construction methods do not compromise the quality of the occupants’ life but add to it – creating adaptable, flexible spaces that are designed for sustainable modern living. The “Lighthouse” has two bedrooms and a total floor area of two and a half storeys with approximately 100 square meters. Specific requirements are reflected in the architecture of the house, which solve some of the things a little differently from the standard model of housing, such as the location of all floors at ground level. Residential areas are located at the top floor, where they can utilize the most of natural light coming through windows and skylights.

House has been designed in line with Lifetime Homes and Housing Quality indicators. The home boasts high levels of thermal insulation, passive cooling and ventilation, biomass boilers and so on. 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. (*the term “zero” is pure marketing designation, due to the fact that it is not evaluated in view of LCA [3]). The house has a waste sorting system that allows to burn a combustible waste and also uses solar system as the solution for water heating, solar cooling, photovoltaic energy systems and heat pump. (all technologies used are suitable for integrating new or even existing buildings). This building is a strategic step towards the house with low or zero-carbon emission*.

Architecture

It reflects the use of specific technologies as well as the actual requirement of creating buildings with low carbon production. The home has a simple, “barn-like” form with a 40 degree pitched roof that includes solar panels and rainwater harvesting. he sweeping roof envelops the central space – a generous, open-plan, top-lit, double height living area, with the sleeping accommodation at ground level. The living space uses a timber portal structure. Stability is achieved through the moment connections at first floor and ceiling level. It is constructed using Kingspan Off-Site’s TEK Building System – a high performance SIPS (structurally insulated panel based system).

For the Lighthouse, this will provide a high level of thermal insulation and performance reducing the heat loss by potentially two-thirds that of a standard house. U values of 0.11W/m_K and air-tightness of less than 1.0m_/hr/m_ at 50Pa. The foundations consist of off site timber floor cassettes on a ring beam of timber beams supported off the ground level by screw fast pile heads. The piles provide minimal disturbance to the ground and provide suitable supports for domestic scale dwellings. When the building reaches the end of its useful lifespan, the fast foundation support point can be removed.[AAA]

Selective thermal mass

Phase changing material in the ceilings absorbs the room heat by changing from solid to liquid within microscopic capsules embedded in the board. This process is reversed when the room is cooled with the night air, working with the passive system of the wind catcher.

Wind catcher/light funnel

Located on the roof, above the central void over the staircase, the wind catcher provides passive cooling and ventilation. When open, this catches the air forcing it down into the hearth of the house, to the living space and the ground floor sleeping accommodation, dispersing the hot air, slowing it to escape. The wind catcher also brings daylight deep into the plan of the house and provides the ground floor sleeping accommodation with secure night-time ventilation.

Services and energy

Integrated with smart metering and monitoring which records energy consumption and enables occupants to identify if any wastage is occurring, thereby helping to promote more environmentally aware lifestyles. Renewable energy is provided by a biomass boiler with an automatic feed system for heating. Photovoltaics provide all electricity for the home and a solar-themed array, which supplies hot water and allows the boiler to be turned off in the summer. The roof-mounted wind catcher provides secure night-time ventilation for passive cooling, in conjunction with thermal mass boards in the ceilings and external shading. This helps to control the temperature of the interior environment, improving occupier comfort and keeping the house cool in the summer months.

These renewable energy features have reduced energy fuel costs for space and water heating in the Lighthouse to around 50 € per year and, as all electricity is supplied via

solar technologies, electricity running costs are completely eliminated. The overall cost of fuel in each house has been reduced by about 94% (not including standard charges). Time horizon for return on investment, however, is likely to exceed the lifetime of building (this fact usually occurs always in development solutions), but just such a development studies undercut subsequent wider solutions use.

Zero House? Reality or fiction?

We try to analyze more in detail, whether it is really a zero house (in terms of CO_2 production).

"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."

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 [2], pelletising – chipper, pelletizing machine, etc.). Each process produces CO_2 in a certain way therefore the advertisement:

"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"

Is very misleading in terms of overall production of carbon dioxine. 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 time of the building use.

Each element (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) … 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) [3]

Life cycle assessment

A life-cycle assessment (LCA, also known as life-cycle analysis, ecobalance, and cradle-to-grave analysis)[4] 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).

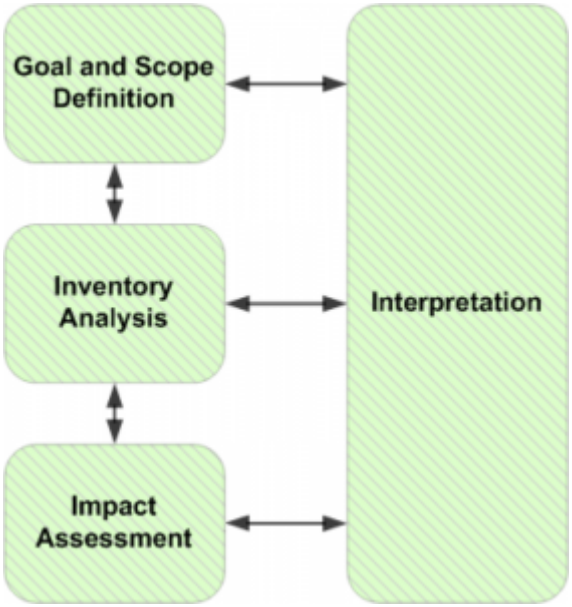
Goals and purpose

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.

Attributional anda 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: oriented to the future, which 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[3] and 14044[4] 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.

Life cycle inventory

Life Cycle Inventory (LCI) analysis involves creating an inventory of flows from and to nature for a product system. Inventory flows include inputs of water, energy, and raw materials, and releases to air, land, and water. To develop the inventory, a flow model of the technical system is constructed using data on inputs and outputs. LCI covers the full range of inputs and outputs, typically aiming to account for 99% of the mass of a product, 99% of the energy used in its production and any environmentally sensitive flows, even if they fall within the 1% level of inputs.

Life cycle impact assessment

Inventory analysis is followed by impact assessment. This phase of LCA is aimed at evaluating the significance of potential environmental impacts based on the LCI flow results.

Interpretation

Life Cycle Interpretation is a systematic technique to identify, quantify, check, and evaluate information from the results of the life cycle inventory and/or the life cycle impact assessment. The results from the inventory analysis and impact assessment are summarized during the interpretation phase. The outcome of the interpretation phase is a set of conclusions and recommendations for the study.

A key purpose of performing life cycle interpretation is to determine the level of confidence in the final results and communicate them in a fair, complete, and accurate manner. Interpreting the results of an LCA is not as simple as “3 is better than 2, therefore Alternative A is the best choice”! Interpreting the results of an LCA starts with understanding the accuracy of the results, and ensuring they meet the goal of the study.

*** 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 [6][7]But the use of solar cells is still controversial.

Advantages of using the LCA

LCA Helps to Avoid Shifting Environmental Problems from One Place to Another [8].

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. [5].

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).

Consideration of the life cycle of the zero house

According to the principles of LCA seems to mark the house "Lighthouse" as a "zero house" as meaningless and misleading. If we consider the production of emissions (eg CO2) and energy efficiency in buildings, we must consider more factors than just CO2 emissions from the moment of taking the building. Similarly, it would seem nonsensical designation "Zero electric car", which has zero fossil fuel consumption, but its production and development and recharge batteries consumed by more fossil fuel than traditional car operation. (70% of world electricity is produced from fossil fuels, therefore an EV battery charging 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. Nowadyas 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 is 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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