Towards Sustainability – Zero Emission (ZE) and Life Cycle Engineering (LCE)

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One of today's most pressing tasks is to create a sustainable society. The environment needs to be protected and natural resources have to be saved for future generations while at the same time the economic interests of the companies have to be secured and employment has to be created. Many different steps towards the goal of sustainability have been suggested. A method for evaluating these steps is needed.

In the last years the approach "Zero Emission (ZE)" has been developed from a catchword describing an unreachable utopia to a complete practical approach set up to realise a sustainable society. The original ideas behind ZE as developed in 1993 at the United Nations University in Tokyo are:

- Identification and development of new value-added products from existing waste streams or under-exploited by-products.
- Creative search for completely new educts and products.
- Implementation of breakthrough technologies.

But in this approach a method for a view in systems and the evaluation of the proposed steps towards sustainability is missing so far. Therefore the basis of ZE should be the thinking in life cycles, a quantitative optimisation potential analysis and the evaluation of the whole system. This life cycle view is important to avoid the often criticised movement of environmental and other burdens from one place or media to another.

Life Cycle Engineering (LCE) is a tool for such a system analysis, for evaluation that can be used for decision support. LCE combines the well-known tools of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC) with technical data. With the LCE methodology, decision support is given from the point of view of environmental, economical and technical aspects. Usually LCE describes the life-cycle of a product, system or service from raw material through production, use and disposal, or in other words, from the cradle to the grave. But it can also be applied to complete industrial networks or for benchmarking single processes.

The environmental side of LCE is already state of the art, the international standards for conducting an LCA study are described in the ISO 14040 series. For conducting an LCA study it is necessary to perform a compilation and evaluation of the inputs and outputs and the potential environmental impacts associated with every single process step of the production and throughout the life cycle of the product. All the material and energy flows, as well as the relevant environmental releases involved in the complete life cycle of the product are identified, quantified and characterized.

The usual steps of an LCA (see also Illustration 1) as described in ISO 14040 ff. are:

- The definition of goal and scope of the study.
- The Life Cycle Inventory (LCI), which means the compilation of an inventory of the inputs and outputs of each step of the process.
- The Life Cycle Impact Assessment (LCIA), where potential impacts on the environment are associated to the inputs and outputs.
- The analysis and interpretation of the results.

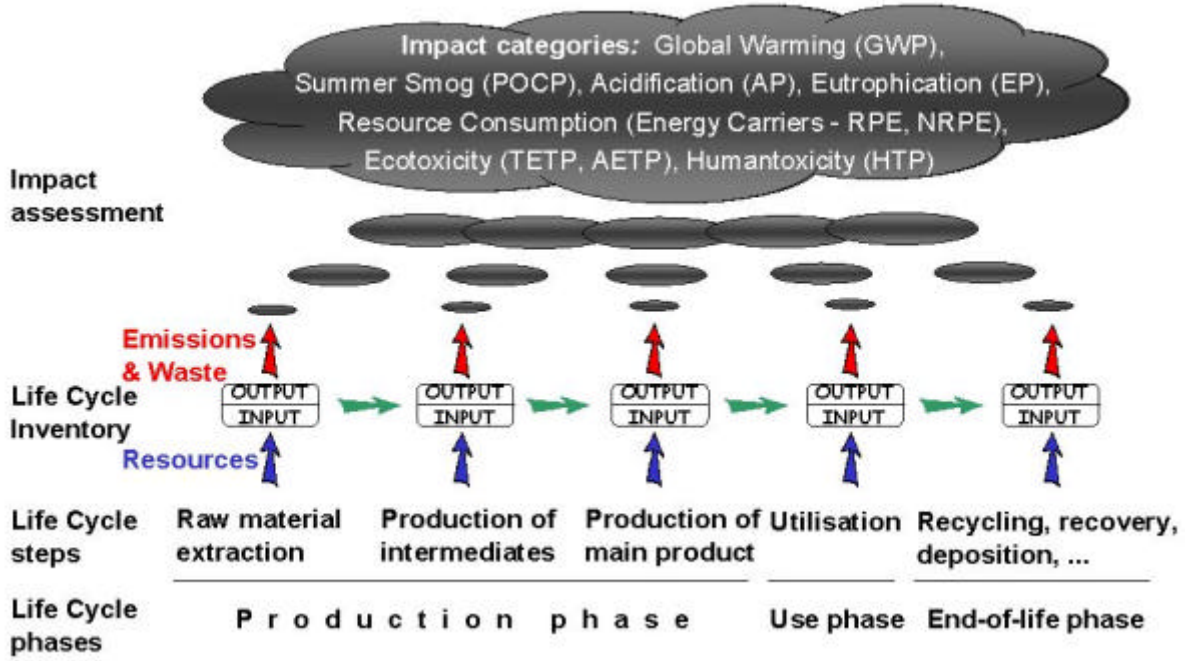

Illustration 1: The life-cycle of a product

In addition to this extended ZE-approach based on a life-cycle view, it has to be underlined that ZE is also a highly integrative approach regarding the participating partners. Industry, science and politics/non-governmental organisations should actively be involved in the analysis and improvement of the system. A socio-economic viewpoint is added by analysing employment effects of the system along it's whole life cycle. Moreover, practical concepts of teaching sustainability and the thinking in life cycles to the youth are developed.

The Method of ZE shall be demonstrated regarding an industrial project, a polymer on the basis of lignin. During cellulose-production a high amount of spent liquor is produced. This waste stream is usually burned to recover energy. But due to its high content of water and sulphur, this is an energetically inefficient and environmentally not sound use. Instead the ligno-sulfate in this liquor can be turned into a raw material for a natural fibre reinforced thermoset polymer. This polymer can be processed like a thermoplastic material with conventional extruders and injection moulding machines to high-value applications. Due to it's properties similar to the properties of wood it can be used advantageously in combination with or as an alternative to wood in the furniture-, electronic- or automotive-industry (e.g. the butt of a rifle or the steering-wheel of a german luxury car).

As an example the production of watch-cases made from a lignin-based polymer will be described. The usual production of watch-cases from ABS is thus substituted, which leads to an improved situation regarding sustainability.