LIFE CYCLE ASSESSMENT OF POWER TRANSFORMERS: an INTRODUCTION

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Preface

Power transformers are electrical equipment with a strategic role in the production, distribution and electricity use. The useful life of a transformer is about 40 years and an analysis of the manufacturing, installation, operation and maintenance, end of life management seems to be a right approach to develop new apparatus with a lower environmental load especially to better control eventual accidents, with particular regard to emissions from the insulating substances, and the end of life of all components (Figure 1).

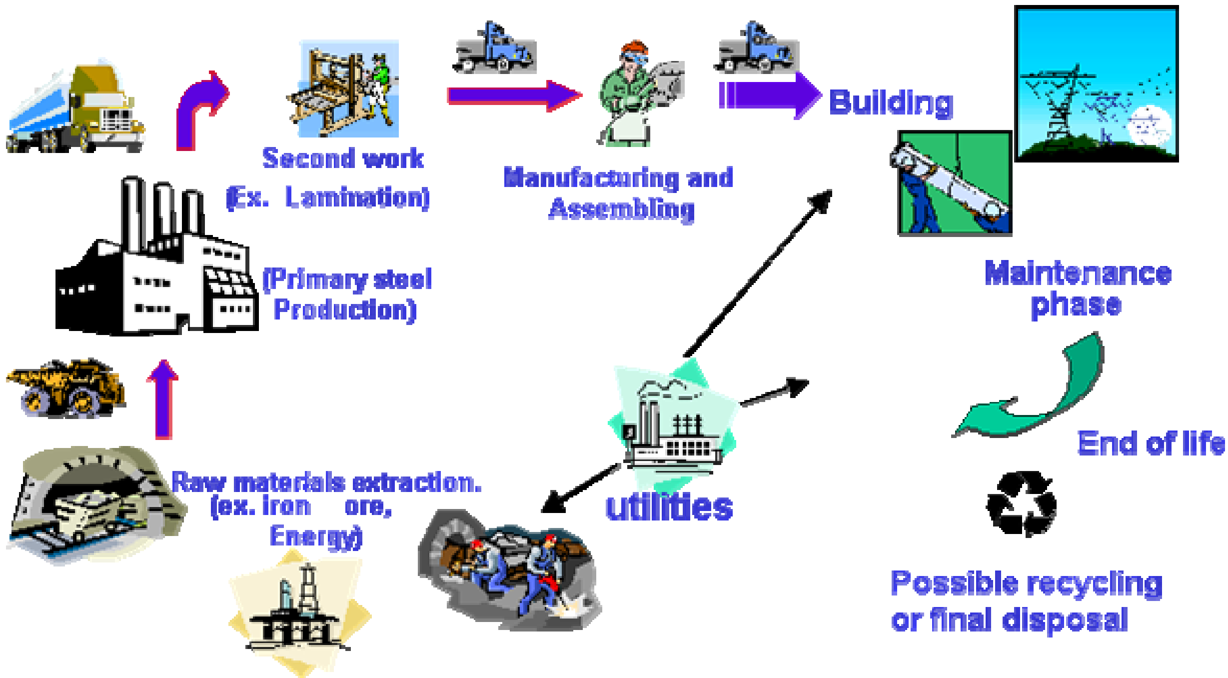

Figure 1. The life-cycle approach.

Life Cycle Assessment (LCA) provides a physical description of the system in a quantitative indication of all flows of materials and energy across the system boundary either into or out of the system itself and is able to calculate the environmental burden of a process and its products.

It was thought helpful therefore to separate this type of work into four distinct stages as shown in Figure 2 (SETAC, 1993; ISO, 1997).

1. **A Goal and Scoping stage –** where the aim is to determine the extent of the work to be done and the procedures to be employed.
2. **An inventory stage -** where the aim is to provide a detailed description of the inputs of raw materials and fuels into a system and the outputs of solid, liquid and gaseous wastes from the system.
3. **An interpretation stage -** where the inventory results are linked to identifiable environmental problems.
4. **An improvement stage -** in which the system is modified in an attempt to reduce the environmental impacts. Once the improvements have been suggested or implemented, the inventory is performed again to see if the expected changes have occurred but also to identify if any unwanted side effects have accidentally been introduced.

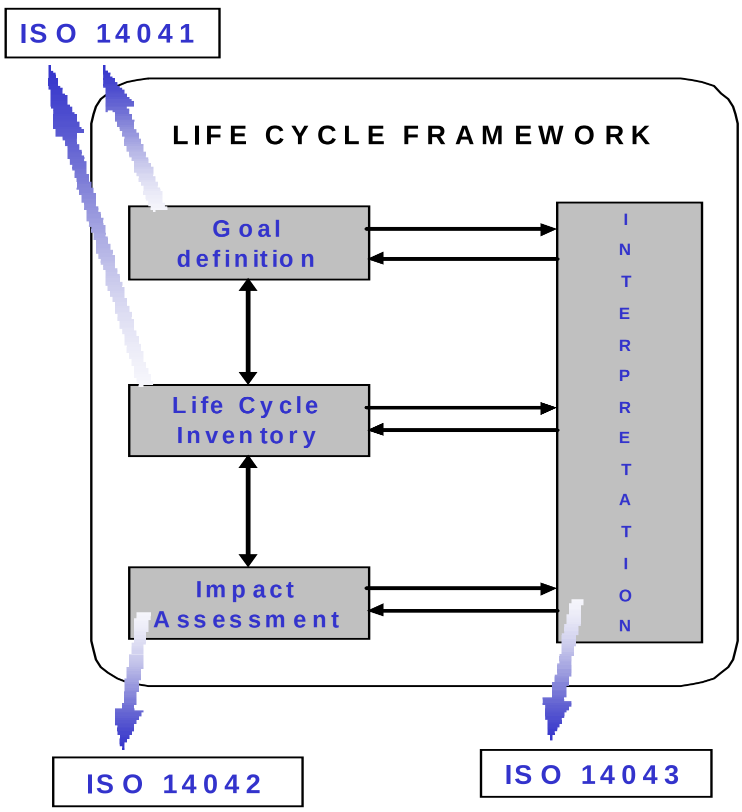

Figure 2. The four main stages of a life-cycle assessment and ISO standards.

LCA can be used to design or improve products and processes, and to develop marketing and supply chain management strategies. The most frequent applications are related to:

- Design, research and development;
- Comparison of existing products or processes with planned alternatives;
- Providing information and education to consumers and stakeholders.

The use of LCA is also increasing due to eco-labeling schemes, government initiatives, product and waste management policies and emerging “green” markets.

LCA approach to transformers

With regard to transformers, since they use as insulating fluids and cooling medium mineral oil, gases like SF_6 or other systems, the initial attention may be given to the quantification of the impacts to the environment due to fluids production, use, maintenance and the of life.

In this case, it can be noted that mineral oil are very cheap but has as main problem the content of PCBs (that are used as an additive) and this means in case of accident (explosion risk) the production of PCDF and PCDD. On the other side, SF6 is a colourless and odourless gas, more expensive than mineral oil, not flammable, that has however to be carefully handled during construction as well as collected at the end of the transformer useful life in order not to contribute to the global warming or any other environmental problem[1].

Testing on new technology can be therefore approached also from a life-cycle point of view and represents an innovative possibility to benchmark different solutions.

Even if the starting point to compare different solutions is commonly based on technical (such as dielectric, mechanical and thermal data) and economic properties, the question of environmentally friendly parameters has arisen when a new more favourable material is looked for.

For instance, in Table 1 some functional properties are given for a group of insulating fluids and some empty boxes are left for an environmental property (in the table the gross energy requirement is chosen as reference indicator) that can be calculated with a life-cycle-approach.

Table 1. Some functional properties (average indicative values) for a group of insulation fluids.

Insulation fluid	**Dielectric (i.e. breakdown field E_b)**	**Mechanical (i.e. density)**	**Thermal (i.e. heat transfer)**	**Environmental (i.e. gross energy)**
SF_6 450 kPa	31	30	4,4	n.a.
Mineral oil	30	860	15	n.a.
Galden	12	1750	15	n.a.

At the same time, the use of materials for the construction of the apparatus as well as strategies for recycling require again a life-cycle approach to address the design (or re-design) phase and end of life management: the production of compact and long-life equipment is a new strong requirement

[1] The GWP (Global Warming Potential) of Sf_6 in case of atmospheric release is 23.900.

that has been recently applied by big industries at world level and that can be fulfilled taking into account design for environment considerations (Figure 3). Environmental responsibility is now considered an important issue within big companies that produce electric equipment.

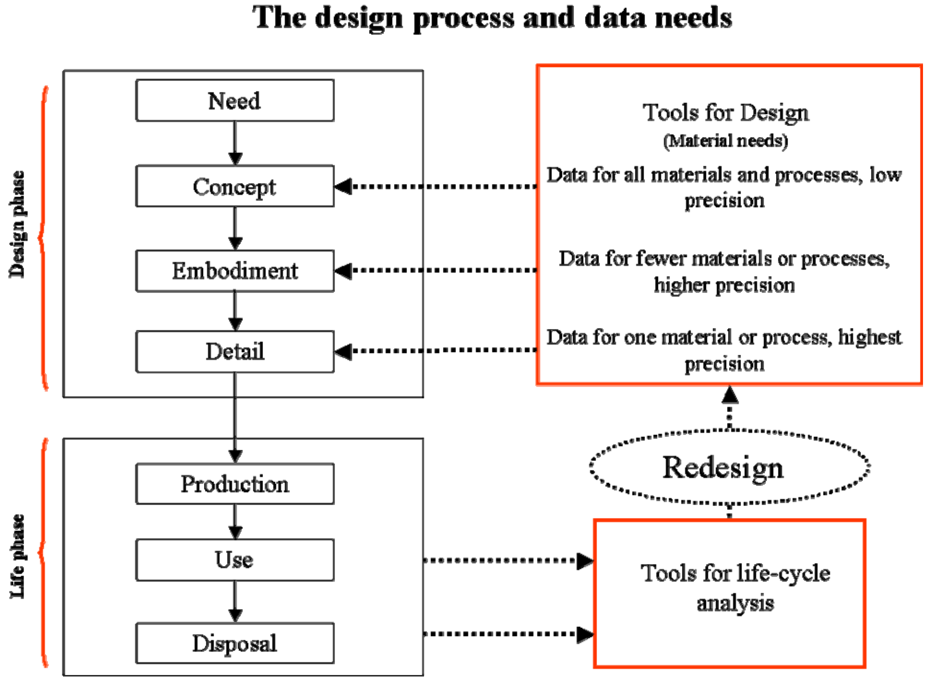

Figure 3. The design approach and life-cycle concept.

Final remarks

A life-cycle-thinking approach for the environmentally correct product design and handling constitute a significant investment for the next generation of power transformer machines with an environmental and economic sustainability. The possibility to access to reliable and rich LCA databases on electric and electronic components let companies and research centres to apply the methodology to the power transformers sector and to transfer environmental indications to the design and maintenance teams.

References

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