

## LCA History: How It Came About

### The Roots of LCA in Switzerland – Continuous Learning by Doing

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#### 1 Scientists and Economists Get Interested in Environmental Impacts

In the sixties, EMPA (Eidgenössische Materialprüfungs- und -forschungsanstalt, Dübendorf and St. Gallen) had its first confrontations with environmental problems. The water-pollution by detergents, the emissions in the air by the traffic and the packaging litter were the first things to be considered. The economists at HSG (University of St. Gallen-Graduate School of Business, Economics, Law and Social Sciences) were – also motivated by the publication of the Club of Rome – interested in the depletion of raw materials and integrated the factor natural resources in their economic system-model.

EMPA as a research and testing institute had to develop methods of control and evaluation. The biodegradability of detergents and control of car exhausts were the first environmental tests implemented. The energy discussions on nuclear and alternative energies (energy scenario Switzerland) and the energy crisis subsequently brought new actuality to the environmental problems. Direct impulses for LCA or ecobalances (as was said at this time) were provided by the scarcity of oil during the energy crisis and severe criticism against the packaging industry. It was said that many products were overpacked and that the preference of disposals was responsible for the mountains of waste and the missing capacities for landfill.

The ecological challenge had a more technical and scientific effect on EMPA and an economic and social aspect on the HSG. The consequence was that an integrated holistic view of the environmental situation and its evaluation according to a sustainable development was needed. It was also evident that technical or end of pipe solutions regulated by directives had to be completed by measurements at the sources. Also for this postulate, LCA seemed to become helpful.

#### 2 Two Fundamental Research Projects

As reported above, environmental problems were no longer quite new. In 1977, two different research projects were then started at EMPA. These two basic studies for LCA

development had different goals and were therefore even allowed to go different ways and to put the main stresses differently.

1. The **BUS-study** (Bundesamt für Umweltschutz) "Ökobilanzen von Packstoffen" was initiated by the government and had to establish a data bank for the most important packaging materials: aluminium, glass, plastics, paper and cardboard, tin plate. This study ended in 1984 with the report SRU No. 24 (Schriftenreihe Umweltschutz des BUS).
2. The **yoghurt-study** was initiated by the industry (dairy, packaging, distributors) and had to compare different types of yoghurt packaging systems in relation to technical performance, costs and consumer's acceptance as the environmental impacts. The goals of this study required a multidisciplinary research, so HSG/ FAH (Forschungsstelle für Absatz und Handel, the marketing specialists) and EMPA (natural science and technology) were entrusted. A report on this topic was published in 1979.

The problems to be treated at this time were not quite new for EMPA, but the knowledge was based more on informative contacts than on our own research work. EMPA reported on the environmental problems with packagings and on possibilities or more recommendations on how to manage them. The Report of the Club of Rome, the publication of R. MÜLLER-WENK "Die ökologische Buchhaltung (ecologic bookkeeping)", a study of the Swiss aluminum foil manufacturers on energy and packaging, and the energy-ethic postulate of DANIEL SPRENG were known and therefore played some influence on the start and procedure of these two research works.

#### 3 The BUS-Study on Packaging Materials

The Eidgenössische Kommission für Abfallwirtschaft (Federal Commission for refuse and waste disposal) needed more details concerning the contribution of packages to the waste problem, the depletion of resources and the pollution. The BUS was project-leader and assisted by a working group which discussed and directed the study, performed at EMPA by WERNER THALMANN and VERENA HUMBEL. The goal was

to get by the government and industry approved data related to the environmental influences of the main packaging materials. EMPA had to review and check all available documents and information related to the need of energy and raw materials, the emissions to water, air and soil in connection with the production of the packaging materials aluminum, glass, plastics, paper, cardboard and tin plate.

Also proposals for an evaluation and weighting of the different environmental impacts were required. The goal was reference information about the most used packaging materials from a common viewpoint which should allow us to attain compatible values suitable for comparisons. The data are given for 1 kg of finished foils or sheets. Such data are specific for materials and not for packaging.

As a guideline for the methodology and as an important source of data, BUS gave the REPA-study (Resource and Environmental Profile Analysis) of the Midwest Research Institute, Kansas City. For that reason, the reports are influenced by the situation in the US. Further information was received from the Swiss manufacturers of aluminum, glass and cardboard and from the German plastic and tin-plate producers.

All unit-processes beginning with the extraction of raw materials and ending with the production of the packaging materials were recorded exactly as far as allowed the information of the industry and in the literature. The input and output of each step was recorded and registered as energy and material flows. It was tiresome work to get comparable and compatible values for all materials.

The proposals for the aggregation and the interpretation of the collected data was a remarkable and courageous step versus impact assessment. They were based on ecological directives on pollution and the scarcity-thesis of MÜLLER-WENK's ecological bookkeeping. The goal to give only one eco-index for each packaging material was too ambitious. No consensus could be found for eco-weighting factors contributed to the different kind of impacts. The data banks therefore provided the following parameters for each packaging material:

- Total energy-equivalent expressed in a virtual thermal primary energy
- sum parameters for the environmental impacts to the compartments water and air, using the legal limits for calculating the so-called critical volumes spoiled by the relevant emissions and summing up all emissions
- the total volume of waste for landfill.

The publication of this data bank by BUS was a milestone in the LCA-history. There now exists a set of official eco-data of the main packaging materials and also directives on how to evaluate the total impacts on air, water and soil (landfill resources). The critical volumes suggest a real polluted volume while today's impact assessments speak of impact potentials.

In the introduction to the data base, the authors accentuated the complexity relative to the use of ecobalances, so that only experts in packaging should use it. Unfortunately, it came just at the beginning of the application of the packaging data to some troubles and controversies.

A practical example should explain the use of the data and demonstrate the possibility of ranking packages in a comparison test. Five different packages for 1 liter milk were compared:

- A bag made of a plastic tube, polyethylene (7 g)
- a light plastic bottle, polyethylene (20 g)
- a Brik-pak paper laminated with polyethylene (25 g)
- a glass bottle, returnable, 20 and 40 cycles (400 g)
- a plastic bottle, polyethylene (48 g).

Using the eco-data of the relevant packaging material and the measured weights of the containers, the closures and the etiquettes, the energy-equivalents, the critical volumes of water and air, and the waste volumes were calculated. The conclusion of this test seemed very simple: the five containers could be classified in three groups:

1. The smallest influence on the environment showed the returnable glass bottles and the plastic bag.
2. The highest eco-impacts were found for the Brik-pak and the plastic bottle.
3. The light plastic bottle had a position between the two extremes.

The surprising fact of this result was that at this time more than 90% of the milk distributed in Switzerland in 1 liter containers was packed in Brik-pak or similar containers.

The media reported this sensational piece of news: The Swiss milk distribution was a flop! The producers and users of these discriminated packages protested and pointed to other studies made for Sweden and Germany which came to quite different conclusions. Who had nonvaluable data? But it was not only the quality of data, the reasons were in the system-boundaries and the sources for data as well. The BUS values were only material specific while the others tested the whole packaging and distribution system. LCA for milk packages done later on explained and confirmed this. The logistic differences are very remarkable between a multiway system with glass containers and a oneway disposable plastic container. The BUS data were strictly relevant only for the Swiss market. Thus, the data for glass is based on a highly ecologic-minded production technique. On the other side, the paper data was compared with data from Sweden or Germany in an upper range.

The publication of this BUS data bank had a remarkable response. The ecobalancers were happy to have officially approved values. The record of a maximum of details describing the different steps in the related technical processes in the EMPA reports for each packaging material guaranteed the needed transparency. The proposed method to

evaluate the environmental impacts as sum parameters was estimated by all who are used to calculate in the manner of an engineer or a bookkeeper. In some way, this philosophy was further developed and refined by AHBE, BRAUNSCHWEIG and MÜLLER-WENK in the SRU report Nr. 132 "Methodik für Ökobilanzen auf der Basis ökologischer Optimierung (Method for ecobalances on the basis of ecologic optimization)" edited by BUWAL (Bundesamt für Umwelt, Wald und Landschaft, formerly BUS). This report proposes the calculation of ecopoints, but not everybody agreed with the sum parameters of the critical volumes of water and air and therefore neglected to practice this data bank.

#### 4 The Yoghurt Study

Toni, an important Swiss dairy, was convinced that glass will be the packing material of the future thanks to its good ecological properties. Toni therefore propagated yoghurt in the glass instead in the polystyrene cup commonly used. This marketing idea was sustained by the Swiss glass manufacturers. The glass industry developed successful eco-strategies and could convince the consumers that glass containers are the best packaging material for sustainable development. The other yoghurt producers and distributors found the polystyrene cups with an aluminum cover to be an optimal type of container for the distribution of yoghurt. Therefore, they decided to clear up this controversy by a neutral expertise comparing the Combiglas (container of brown glass which could be reused, and voluntarily returned with no deposit) against the disposable polystyrene cup.

Representatives of dairies, the glass and plastic industry and the distributors entrusted EMPA and the FAH-institute (Forschungsstelle Absatz und Handel) of the University of St. Gallen with an economic, technical and ecological study on the consequences of a change from the polystyrene cup to the glass container Combiglas. In the period of this study, the energy crisis had brought the plastic market at risk. For this reason, alternatives to polystyrene were also tested: a cup of polypropylene and one of paper.

The given goals made this study packaging and distribution oriented. The total costs of a change including the environmental consequences of the need for new installations and the acceptance by the consumers were discussed. The goal and scope of the LCA, needed for the ecological part of the study, were influenced by the economic consequences and by the technical performance of the evaluated packaging variants.

Here, EMPA was confronted with quite another situation than it was for the BUS data bank. The basic data for the materials, the packaging and logistic processes, and the disposal were taken from the literature or were provided by the industry. They were not so detailed by far as in the BUS study. At the beginning, the industry was also very reserved in providing production information. However, we succeeded in getting much more information by discussing the

literature data with them, so that we could correct older values in the literature, thus mostly reducing them. Great discrepancies existed in the literature which were explained by different points of view and the lack of transparency. It was necessary to prove this by plausibility considerations. It was also important to make the literature data compatible and realistic. It is to say that these plausibility tests were based on the view and the thinking of a chemical-engineer.

The LCA items were discussed with the representatives of industry and trade. This intensive contact with the project group was very positive for planning and establishing the LCA.

The environmental part of the study recorded the energy demand summed up over all steps in form of thermal primary energy in MJ. The emissions were only discussed qualitatively. Since most emissions are linked to the energy input, a quantitative recording of emissions, e.g. in the criterion of critical volumes, seemed to be more misleading than a purely qualitative record. Also the depletion of resources was discussed. Of course, the energy consumption became the most significant feature in this procedure.

Taking a retrospective look into this initial LCA-activity, it is evident that the need to debate ecological consequences of different distribution-systems showed many of the LCA problems for which we are searching solutions or a way to manage them.

The importance of a holistic approach was evident. Only the discussion of the whole distribution system could give a real picture of the expenditure and the benefit. The formulation of the goals, that means the problems to be solved, is extremely decisive for the system boundaries, the data set to be recorded and the evaluation criteria. The packaging performance is influenced by the product, the production processes, the distribution and the consumption and must be in order before an ecological evaluation can be performed. Only this gives a realistic answer to the interesting questions.

The yoghurt study had to consider different subsystems:

- The packaging materials and the design (form) and weight of the container used
- the problem "returnable versus disposable"
- the expenditures for packaging, storing and distributing
- the possibilities of waste management.

The interlink of the subsystems and the target of a complete record of all material and energy flows from the cradle to the grave lead to a high complexity which can only be reduced by adapting the system boundaries and the number of inputs and outputs to be registered. If such an adaptation to the goals is omitted, the task cannot be fulfilled in a realistic time and at an acceptable price. Thus, a decision was made to record the following items in the yoghurt study:

- The energy consumption, including the feedstock energy, is related to a virtual thermic primary energy. Based on thermodynamic arguments, this expenditure was taken as the most important (energy-ethic postulate of D. SPRENG: all human activities for a given benefit should be linked with a minimal energy flow). At the period of this study, the Swiss energy scene was intensively discussed and an energy concept was elaborated. Thus, the viewpoint of the value of the different kinds of energy was also integrated.
- Pollution was only discussed qualitatively. The data disposable were incomplete. The emissions in the air were very closely linked to the energy forms used and the chosen energy scenario. The sum-parameters of the BUS-study, the critical volumes, were judged to be too problematic. The renunciation of a quantitative record was also given reason by the fact that pollution is widely regulated by law.
- The availability of the different raw materials was also discussed. The existing differences between the resources were found to be not so decisive so that one or another material should be substituted. The depletion of oil for the production of plastics therefore lays in an acceptable range.

The evaluation and interpretation of the results received considered that the calculated energy demands showed a remarkable deviation-range (about 20% were admitted). That was the reason why ranges instead of strong numeric values were compared. In addition, sensitivity tests were made in respect of changing the design, reduction of weight and return, and reuse quotes of the glass containers. The two tests mentioned last showed a distinct effect.

Glass or plastic, returnables or disposables? The answer to these questions: both packaging systems lay in the same range in relation to the technical performance and the environmental risks. A further severe finding was that even scientifically elaborated facts cannot assure an open-minded discussion. The presentation of the results of the yoghurt study to the press and the consumers could not convince them that polystyrene cups are as good for the environment as glass containers. The glass was unanimously preferred by the participants of the information meeting. This confirms that a successful marketing for a product leads to bias and that complex systems discussed and explained from different view points are hardly or only in a misleading way understood by the broad mass of the population. The public reacts only to eye-catching and simple messages, and such reactions are mostly very general and rashly.

## 5 A Situation Typical of Switzerland

The development of LCA methods in Switzerland may be classified typical for the Swiss mentality. Swiss people are on one side said to be extremely exact or even pedantic and seem to bear all details in mind. Clear regulations and rules

on how to do the work are striven for. It is the job of an engineer or bookkeeper to quantify all things as far as possible and to use a formula for calculating the risk. This mentality was the philosophy of the BUS data bank and the proposed sum parameters of critical volumes and energy equivalents. AHBE, BRAUNSCHWEIG and MÜLLER-WENK perfected this trend by the creation of the eco-points.

On the other side, the extremely democratic thinking and respecting of minorities forces the Swiss to take all different views and possibilities into consideration, a situation which often leads to compromises or pluralistic solutions. Such a kind of LCA work which is not only related to the potential environmental effects, but also strives for a technical, economic and social feasibility was the yoghurt study, initiated by industry and trade and carried out by the EMPA and HSG/FAH. This way to solve the problem is no more an ecobalance in the stricter sense, but rather a quality management including performance, economy and ecology.

A result of this thinking was the propagation of the optimal packaging model. The strong critics against packaging were a motivation to give a paper on "Packaging in a general view" at a meeting of the Swiss Packaging Institute in May 1982. Compliments, but also rebuke made in relation to the packaging, were discussed. As a contrast to this black and white visualisation, a more differentiating and systematic evaluation method for packaging systems was developed. This Optimal Packaging Model was characterized by three dices "performance", "expenditure" and "proving by use". The dice was taken as a symbol to express that every thing has more than only one side to look at. LCA was therefore one aspect of "expenditure" aside from the costs or the infrastructure. The ecostrategy became one element of the quality management.

Both of these two typical Swiss extremes of LCA methodology received a remarkable international response. The Swiss data bank for packaging materials and the sum parameters linked to them were used widely, but of course also criticised. For practical balancing work, these official data provided a trusting base.

The integration of LCA in the quality management, and the statement that LCA is an important and helpful, but not the only valuable element for realizing a sustainable development, brought contacts and participations in international expert groups.

For the further development of LCA-methodology, the reported duality had two effects. It complicated the efforts for a broad consensus in LCA-methodology and thereby hindered a too detailed standardisation of ecobalances in a short time. On the other side, the possibilities and limits of LCA were seen clearly as well. The risk of being blinkered in one's work was banned.

Thus, the roots of a scientific research can also influence the shape of the tree and its fruits as result of the research.