LCA History

LCA – How it Came About

– Personal Reflections on the Origin and the Development of LCA in the USA

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Abstract

This article is the personal reflections of the authors on the 25-year history of LCA in the U.S.A. The original study was commissioned by The Coca-Cola Company in 1969. While most LCAs in the U.S. have been confidential studies for private companies, important public studies are described. In the early years, the LCAs were generally commissioned by clients who were interested primarily in the solid waste aspects of total manufacturing and use systems, especially for packaging products. The energy and other environmental information was just a "bonus." In about 1975, the interest turned to energy. In 1988, the primary interest returned to solid waste, but was quickly replaced by a more balanced concern about the broad areas of resource use and environmental emissions. This broader interest has sparked the current debates in impact assessment.

Key words: Life cycle analysis; life cycle assessment; life cycle inventories; environment; energy; natural resources; energy; pollution; solid waste

The idea of comprehensive environmental life cycle assessments (LCA) was conceived in the U.S.A. in the late 1960s and early 1970s. While nearly identical ideas were being developed in Europe at approximately the same time, this paper only addresses the development of LCA in the U.S.A. This is a personal reflection by the authors, covering the period from 1970 to 1990. During that time, there was little public attention and very little written about LCA. Since 1990, the history of LCA is very well documented and is not addressed in this paper.

The idea of the complexity of environmental issues was likely first realized by the scientific community in the 1960s. However, the formal analytical scheme that was to become LCA was first conceived by Harry E. TEASLEY, Jr. in 1969. At that time, he was managing the packaging function for The Coca-Cola Company. Over a period of many months he visualized a study that would attempt to quantify the energy, material and environmental consequences of the entire life cycle of a package from the extraction of raw materials to disposal. At that time, The Coca-Cola Company was considering whether they should self-manufacture beverage cans, and was looking at a number of issues relating to package manufacture. This encompassed analysis of all issues that were pertinent to that decision, including environmental consequences of manufacture and use of packaging. In addition, the possibility of using a plastic bottle was being considered, which was a revolutionary idea at that time. Identifying the key issues relating to the use of refillable bottles as compared to disposable containers was an important part of the deliberations.

One of the innovative ideas at that time was the inclusion of energy in the natural resource category. At that time, there was no focused interest in energy as an ecological issue. The OPEC boycott and the long lines at gasoline stations were not even imagined. National policy was aimed at increasing consumption of energy resources for economic reasons. TEASLEY, however, saw that energy resources inter-related with material use, and he wanted to know the implications of using various packaging options. For instance, hydrocarbon resources used for plastic bottles could be used to melt minerals to make glass bottles.

He knew the process of definition and analysis would be very complex, and that incorporating the results in strategic analysis would be difficult. He was not sure that the data could be gathered or how the details would be worked out. He brought his concept to Midwest Research Institute (MRI), a contract research organization located in Kansas City, Missouri. He presented his ideas to Arsen DARNAY, Assistant Director of the Economics and Management Science Division. DARNAY, a creative thinker like TEASLEY, agreed to work with TEASLEY to design and carry out the study for The Coca-Cola Company. Before the study was completed, Bill FRANKLIN, then a program manager at MRI, was brought into the study. Shortly after, Bob HUNT was transferred in from the Physics Section at MRI to provide technical expertise in the growing program of solid waste and environmental analysis.

DARNAY had little interest in technical details and did no more work on LCA once the Coca-Cola study was completed. He soon left MRI and held administrative positions

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at the federal Environmental Protection Agency (EPA) shortly after it was formed. (This appointment brought him back in contact with MRI in 1972 for another major LCA study on beverage containers.) Subsequent LCA studies and concept development at MRI were done by FRANKLIN and HUNT. As a historical note, the term LCA first came into use in the U.S. in 1990. The historical term for these environmental life cycle studies was resource and environmental profile analysis (REPA), a term that has been used since 1970.

The Coca-Cola study was never published because of its confidential content, but was used by the company in the early 1970s as an input into their many packaging and business decisions. A summary of the study was released in June 1976 to the Office of Technology Assessment of the U.S. Congress, and an article on the subject appeared in the April 9, 1976 issue of Science Magazine. No further dissemination of that study ever occurred. One of the interesting outcomes of the Coca-Cola work was that they gained a "comfort" with the idea of switching from glass to plastic bottles. Previously, plastics had a reputation as somewhat of an environmental villain, but the REPA study showed that this reputation was based upon misunderstanding.

About one year after the first work at MRI, the concept was developed independently at two universities in the U.S. Both of these were engineering student projects. One was led by Professor Bruce HANNON at the University of Illinois, and the other was conducted by a group of students living together at Stanford University in a group known as Ecology House. Both of these groups studied life cycle energy of beverage containers.

After the Coca-Cola study, there was a steady flow of REPA studies at MRI. In the early 1970s, the driving force became solid waste issues. People were very interested in the total life cycle manufacturing system aspects of solid waste in comparison to the postconsumer solid waste. The role of recycling and use of reusable products to reduce solid waste were of particular interest. The inclusion of energy and other environmental emissions were not considered by many to be as important as solid waste.

The second REPA study to be completed at MRI was sponsored by the Mobil Chemical Company. They manufactured polystyrene foam meat trays on which meat was wrapped for sale in grocery stores. The manufacturers of the competing molded pulp trays were telling their customers that the plastic trays were a serious environmental problem. The Mobil staff actually thought it was probably true, but wanted to know just how bad it really was. They commissioned a REPA to find out. Much to their surprise, and ours, the plastic tray compared quite favorably. The reason was that the foam tray was very lightweight, and used very little material as compared to the much heavier pulp tray. The Mobil people told us that the results of the study had a profound effect on morale, because their staff had assumed their product was an "environmental villain." They were very pleased to find that there were some desirable environmental attributes to their product.

At about the same time, MRI was commissioned by an executive agency of the U.S. government, the President's Council on Environmental Quality. They provided policy analysis to the Office of the President of the U.S. They asked us to do a series of REPAs on recycling of various materials, once again primarily because of their interest in solid waste.

One of the interesting aspects of these early studies was performing the calculations without the aid of electronic computing equipment. The many hundreds of calculations were done on a mechanical calculator that did not even have a paper tape print-out. It consisted of electric motors and rotating wheels. Whenever an error was found and values had to be recalculated, it was a very time-consuming task. In 1973, the first LCA computer program was funded by an MRI client. The data filled several boxes containing many hundreds of punched cards. The information on the cards had to be loaded into the computer with a mechanical feeder any time we wanted to do calculations. Often the feeder would not read one or two cards correctly, and we had to start all over. The computer would often just tell us there was an error "somewhere," which meant we would have to hand sort through the boxes of cards and try to find the card error.

From 1970 to 1974, the modern concept of REPA/LCA took shape. Also, during that time, a framework for impact assessment was developed. Unfortunately, until 1974 all of the projects were done for private clients, and none were published in their entirety for public reading. However, a series of publications did appear starting in 1972 [1,2,3,4,5] which presented large portions of the database and described the methodology in detail.

In 1972, one of the landmark REPA studies was initiated by Arsen DARNAY, then a deputy assistant administrator for solid waste at EPA. The Office of Solid Waste at EPA was embarking on a program designed to initiate regulatory activity for the packaging industries in the U.S. The starting point was beverage containers. In late 1972, discussions were held with MRI to complete a REPA for beer and soft drink containers. EPA's intent was to examine the environmental implications of using refillable glass containers instead of disposable cans and bottles. At that time, refillable bottles were being rapidly replaced by non-refillable containers. If the REPA came out in favor of refillables, a policy option for EPA might be to select some regulatory mechanism to reduce the viability of disposable packaging, perhaps by selective taxes, subsidies, or by direct regulation.

This was by far the most ambitious REPA attempted up to that time. It involved the glass, steel, aluminum, paper, and plastic industries, and all of the suppliers to those industries. Over 40 materials needed to be characterized. Energy and environmental data also had to be developed for national fuel, transportation, and electricity operations. Some of the data had been developed previously, but this time there was intense scrutiny by EPA, the major industries involved, and environmental organizations. Many meetings were held to discuss methodology, data sources and analysis procedures. Appendices which contained all

of the data for each of the container systems were developed. These appendices underwent intense peer review by a number of industry experts, by EPA staff, and by environmental organizations. All parties had access to the entire database so that there was extensive cross checking and verification of the data.

After the extensive peer reviewing process on both data and methodology, EPA produced the report "Resource and Environmental Profile Analysis of Nine Beverage Container Alternatives" in 1974 [6]. This report was not only produced as a public EPA report, but was also made available to the public through the National Technical Information Service (NTIS). The report is quite comprehensive, including the entire database at that time, and a complete description of methodology. This marked the entry of LCA into the public domain in a comprehensive and peer reviewed document. A summary of that work was also published in a chemical industry journal in 1975 [7].

The results of that report held some surprises, as is often the case with REPA studies. Everyone assumed that a refillable bottle would be clearly superior. However, at that time there was still some use of an all-steel can, one that did not have an aluminum lid. In an era of petroleum and natural gas shortages, the all-steel can used less of this hydrocarbon energy than other container systems and produced very little water pollution. However, the popularity of aluminum pull tab lids soon led to the demise of the all-steel can. The steel and can industries tried for many years to make a successful pull tab lid from steel, but never succeeded in marketing the product.

An interesting aspect of the EPA report was the use of a primitive impact assessment. In the original Coca-Cola report, a set of numerical equivalency factors was used to produce a single index value for each container system. This system had undergone refinement and development, and was used in the EPA report. This marked the first use of impact assessment techniques similar to many that have been proposed in recent years. Soon after the publication of the EPA report, we abandoned the impact assessment procedure. We concluded that the data used to develop the equivalency factors were not sufficiently accurate to produce credible results. We have periodically re-examined this approach over the years and still believe this is true with regards to single value descriptors.

After the successful completion of the beverage container work, EPA initiated a REPA on a variety of reusable and disposable products with MRI, and another study on five types of milk containers. In January of 1975, Bill and Marge FRANKLIN started Franklin Associates, Limited (FAL) and, with Bob HUNT, began conducting REPA studies. The EPA work on disposables and milk containers was completed as a joint effort between FAL and MRI.

These projects marked the end of the interest by EPA in REPA until quite recently. EPA decided in 1975 that using LCA as a regulatory tool was impractical. First, REPAs would need to be done on thousands of products. Using the results of these REPAs, the attainment of regulatory goals would then involve extensive micro-managing of private businesses. This was not feasible. EPA policy shifted to broader issues. If reducing solid waste and conserving energy were important, then energy conservation and solid waste reduction goals should be set, rather than regulating thousands of specific products to reach the same goal. Thus, EPA's focus shifted away from specific products to the more general issues.

Another important change occurred in 1975. Because of the energy crisis, there was intense interest in the energy portions of LCA. At the same time, there was a general feeling that much progress was being made towards alleviation of environmental problems. There was a growing feeling that the emissions portions of an LCA were not as important because regulations and voluntary reductions of emissions were bringing air and water pollution under control. At the same time, energy resources were in critical short supply. This ushered in an era in the U.S. of energy profile studies, which were the energy portions of LCAs.

Once again, comprehensive databases and a complete explanation of methodology was entered into the public domain through work done on beverage containers by the newly formed U.S. Federal Energy Agency (a precursor of the Department of Energy). The report was issued in September, 1976 [8]. The prime contractor, Research Triangle Institute, performed economic studies, with Franklin Associates as the subcontractor performing the energy studies. The report is still available through the National Technical Information Service.

What followed was a lengthy period in which the public sector in the U.S. lost interest in the LCA concept. Many studies were done for private companies who were interested in scientific energy and environmental databases for their products. The predominant application was during research and design of new products. Companies were interested in developing products which produced less environmental insult than existing products, and recognized the usefulness of LCA as one of many tools available to them. These studies were held confidential.

An exception to this private confidentiality was a report issued in 1980 by the Solar Energy Research Institute, a Department of Energy laboratory [9]. This was yet another entry into the public domain of a very comprehensive peer reviewed LCA database that covered the major commodity raw materials. It is over 200 pages of data tables and explanations, including 20 pages of references.

Another major report was completed in 1978 for Goodyear Tire and Rubber Company [10]. This was a study on 2 liter plastic (PET) soft drink containers, and played a role in the initial marketing of that container. The purpose in using this report was to provide a database that showed that the container presented no more threat to the environment than competitive containers. The study was never released in its entirety because of confidential data.

There was a long period of low public interest in LCA from 1975 until 1988. Public attention and government environmental activity was largely diverted to hazardous waste and other toxic waste issues. Even though there was little

public comment about REPA, there was never a time when Franklin Associates was not working on at least one REPA study. Private businesses and trade associations recognized the value of REPA in both long-term strategic planning as well as in design and planning for specific products. Thus, there was a long period of concept "fine tuning," along with constant updating and peer reviewing of the database.

The public frequently misunderstands the fact that most REPAs have never been made public. There is a perception that REPA has primarily been used by companies as an aid to marketing. Nothing could be farther from the truth. Most REPAs contain both "good news and bad news" for companies, and are not suitable as marketing tools. Most companies use REPA as an internal tool to give environmental perspective to their planning. Of the more than 200 studies we have completed, only a very small number have been used publicly.

In 1988, there was a dramatic re-awakening of environmental consciousness in the U.S. It did not have a single source, but rather a number of factors converged to create national debate and extensive media attention. The most visible media trigger was the "garbage barge" incident where a barge loaded with garbage was floating on the high seas from one port to another because no one would accept it. This inflamed national interest and brought our solid waste crisis to a public that had ignored the problem previously. At the same time, a lot of pressure was being felt by multi-national companies because of environmental activity in Europe. There was also a simmering discontent in many environmental organizations about many issues which they felt were unresolved by public action.

There was an explosion of activity in REPA. At first, solid waste was a key driving force, especially with regards to how recycling, material substitution, and product reuse might reduce dependence on landfilling. REPA was looked upon as a way of studying what other effects might occur if these waste reduction alternatives were implemented. The concept of REPA was rediscovered by many public and private organizations.

In May of 1990, the public reappearance of REPA in the U.S. was marked by the convening of an international forum by The Conservation Foundation in Washington, D.C. An invited panel publicly debated the potential role of REPA in resource and environmental policy. This was followed in August of 1990 with the first workshop of many to be convened by the Society of Environmental Toxicology and Chemistry (SETAC) for open debate and discussions on REPA. One outcome was the subsequent adoption of the term "LCA (life cycle analysis)" to designate the REPA concept. In 1992 Franklin Associates authored an article which was the first complete presentation of LCA methodology to appear in a peer reviewed scientific journal edited in the U.S [11].

In the same time frame, EPA initiated activity in LCA after a hiatus of 15 years. In 1991, EPA had a very different purpose than its involvement in earlier years. Rather than using LCA for regulatory activity, EPA is primarily interested in assisting in the development of guidelines and databases for use by interested public and private parties. Their activity resulted in the publication in 1993 of an inventory guidelines document, which has been followed by related documents. At the present time, the U.S. Department of Energy has joined EPA in developing LCA concepts, tools and databases for use by the private sector, and many private consultants are actively engaged in LCA. The emergence of the high degree of interest in the atmospheric and waterborne emissions of LCAs has sparked renewed debate of impact assessments, as we struggle to understand the meaning of these studies.

Working in LCA for 25 years has been an exciting experience. We have seen it grow from an academic seed of an idea into a very popular analytical technique available to many. We have seen the inventory methodology develop into a mature process that enjoys general scientific acceptance, although debate will certainly continue over a few details for many years. We welcome the challenges of now focusing more on methodologies of impact assessment, data quality analysis and on streamlining methodologies as scientists, engineers, and other professionals struggle with these vital issues.

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