Overview: LCA in South Africa

Status of Life Cycle Assessment and Engineering Research in South Africa

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Abstract. In view of the upcoming 2002 World Summit in Johannesburg, sustainable development is a topic of high priority in South Africa. Although the South African competency in Life Cycle Assessment (LCA) and Life Cycle Engineering (LCE) has grown to some extent over the last ten years, South African industry and government have been slow to realise the benefit of LCAs and LCE as tools to support cleaner production and sustainable development. However, the local application of these tools, as well as considerations during their use, differs from practices in developed countries. The applications of LCAs and LCE, the type of organisations involved and the limitations and common problems associated with these tools in South Africa are discussed.

Keywords: Applications; cleaner production; Design for Environment; government; life cycle assessment (LCA); life cycle engineering (LCE); limitations; problems; South Africa; sustainable development; World Summit

1 Introduction

1.1 The nature of production and consumption in South Africa

Historically, agricultural production and mining activities strongly dominated the South African economy [1]. The largest agricultural exports arise from maize and wool, but forestry, sugarcane, as well as fruit and wine constitute other significant activities. Disproportional to its geographical size, South Africa has an immense concentration of the world's mineral wealth, the most important being chrome (72% of the world's reserves), platinum (88%), gold (40%), vanadium (45%), manganese (83%), alumino-silicates (35%), zirconium (26%), vermiculite (40%) and gem diamonds (largest reserves). As is shown in **Table 1**, the above mentioned two primary industry sectors accounted for 25% of the country's Growth Domestic Product (GDP) in the 1960s. However, their importance has reduced to less than 10% of the national GDP by the turn of the century [2].

As the primary sector declined in importance, both manufacturing and the tertiary sector became more important. Prior to the 1990s the manufacturing sector was dominated by heavy industries relating to petroleum, chemical and metallurgical products. Economic sanctions in the latter half of the 1980s resulted in substantial government support for this industry sector through economic incentive schemes, especially with regards to energy supply. Due to the country's large coal reserves, the electricity and manufacturing industries now greatly rely on this resource. An example is the production of aluminium. Although South Africa has no reserves of bauxite, more than six hundred thousand tonnes of aluminium are produced on the South African east coast annually, which is made possible through low-cost electricity supply. In turn, nearly 90% of the electricity supply in South Africa is based on coal-fired technology [3]. Additionally, one-third of the country's fuel and most of the petrochemical products are produced from coal [4]. South Africa ranks amongst the 20 largest CO_2 emitting countries.

The 1990s have seen a turn in the manufacturing sector. Although this sector as a whole contributes 27% to the total GDP, less than 4% of the total GDP is attributable to the chemicals manufacturing industry [5]. The metallurgical industry still plays an important role, but the export of value-

Table 1: Contribution of industry sectors to the South African GDP

Industry sector	1960	1970	1980	1990	2000
Agriculture, forestry and fishing	12.4	7.9	6.8	4.6	4.1
Mining and quarrying	12.7	9.0	21.1	8.7	5.4
Manufacturing	21.0	23.9	22.5	23.5	26.8
Electricity and water	2.5	2.6	3.1	4.0	3.2
Construction	3.1	4.2	3.3	3.2	2.7
Tertiary sector, including transport, finances, trade, etc.	48.3	52.4	43.2	56.0	57.8

added products has increased significantly since the 1994 democratic elections. This is especially true for the automotive industry, which has seen the introduction of the Motor Industry Development Programme by the national Department of Trade and Industry [6]. Since the start of the initiative in 1995, a 37% increase in the average annual export rate was achieved, with export of passenger vehicles increasing by approximately 185% since 1998. Naturally, this has resulted in the strengthening of the supply chain of the industry in the form of components, etc. The dramatic decrease in the value of the South African Rand currency (30% in the last year) could be positive due to lower and competitive international production costs.

Consumer markets in South Africa are small in relation to world markets. Although the population is estimated at roughly 40 million [7], poverty levels remain high and unemployment has been estimated to be as high as 40%. In terms of impact, environmental issues are thus dominated by production rather than by consumption, although wastage patterns are cause for concern if much desired growth occurs.

1.2 Sustainability issues in the South African context

Although the industrial sector, and especially the newly developed manufacturing sector, incorporates first world technologies, a large proportion of the country and its population are subject to developing country conditions. Of the nine million South African households in 1996, approximately 50% had access to formal energy supply as electricity for cooking, heating and lighting, and 45% had direct supply of water inside the dwelling [7]. Roughly 50% of the households had a means of first world latrine and waste removal services. Despite good advances with the transformation initiatives of the democratic government (e.g. one million homes built and seven million dwellings connected to electricity since 1994), access to these basic services remains on the development agenda. It must also be mentioned that the single largest challenge facing the country at the turn of the millennium is the HIV/AIDS pandemic, which has a significant bearing on the allocation of public resources.

From an environmental perspective, the lack of important arterial rivers or lakes requires extensive water conservation and control measures, and growth in water usage threatens to outpace supply [8]. South Africa has an average rainfall of 500 mm/year and is subject to prolonged droughts. Sporadic wet and dry periods; these, together with land mismanagement, have lead to a dramatic increase in the loss of soil (35%), which is an important agricultural resource [9]. Pollution of rivers from agricultural runoff and discharge from informal urban settlements are other important issues, all of which are dealt with in newly introduced legislation.

Historically, waste management was not given a high priority in South Africa. Consequently, insufficient funds and human resources were allocated to this function and in many instances this neglect resulted in a lack of long term planning, information, appropriate legislation and capacity to manage the waste streams [10]. This issue is addressed to some extent through the new national waste management strategy, an initiative of the national Department of Environmental Affairs and Tourism [11]. These and other sustainability issues will most probably feature prominently in the upcoming World Summit [12] at the end of August 2002.

1.3 South African environmental legislation and its implication on a local LCA/E competency

Development of the South African legislation with regards to sustainability closely follows the international trends [13] (**Fig. 1**). Especially with regards to water and waste, South African policies and legislation have been revised and are up-to-date with those of developed countries. In fact, both the new Water Act and the new National Environmental Management Act, especially in terms of provision for public participation, have been described as very progressive. However, certain other legislation is far out-dated and needs to be revisited, e.g. the Atmospheric Pollution Prevention Act of 1965. In addition, enforcement of compliance to governmental legislation is weak and environmental management is of low importance to industry. Environmental management practices are often driven by concern of international trade barriers or promotion by parent companies, but are well supported by local expertise, particularly in the field of impact assessment and coded management standards.

Recent legislative changes, as well as the internationally ongoing 'greening of industry', have resulted in a slow but increasing recognition of the value of LCAs and LCE as environmental management tools, especially for export-oriented production, but also for local consumption. Similarly, South African competency in LCA procedures has developed slowly since the early 1990s but has grown significantly towards the turn of the millennium.

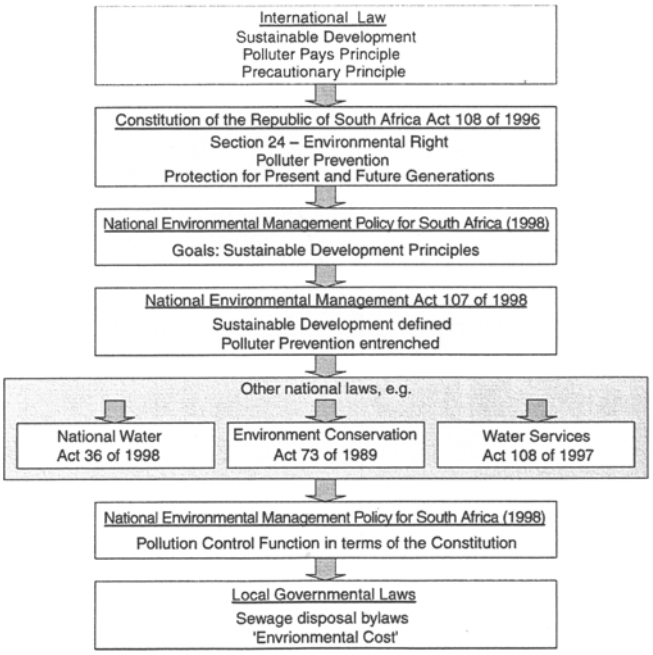

Fig. 1: Legislation framework for sustainable development in South Africa

Table 2: Applications of LCA/E in South African research projects

Application	South African research participants	Level of detail in LCA		
		Conceptual	Simplified	Detailed
Generation of environmental profiles	Petrochemical, metallurgical, paper and pulp, water treatment and cement industries and a power utility. CSIR and Universities of Cape Town, Natal and Pretoria		2	3
Design for the Environment	Petrochemical industry. Universities of Cape Town and Pretoria	3	2	
Decision making for sustainability	Universities of Cape Town and Pretoria	3		
Product development	Not applied	3	1	3
Product improvement	In progress		2	
Environmental claims (ISO type II-labelling)	Application investigated	3		
Ecolabelling (ISO type II-labelling)	Application investigated		2	
Environmental declaration (ISO type III-labelling)	Not applied			3
Organisation marketing	In progress		1	3
Strategic planning	Petrochemical and metallurgical industries and a power utility. CSIR	3	1	
Green procurement	Not applied	3	1	
Deposit/refund schemes	Not applied		1	
Environmental (green) taxes	Not applied		1	
Choice between packaging systems	CSIR, University of Witwatersrand	3		1

Source [15, modified after Jensen et al. (1997)]: **1** Frequent use, **2** Intermediate use, **3** Infrequent use

2 Applications of LCA in South Africa

As a consequence of the focus of environmental concerns on production rather than on consumption, impact assessment and environmental management in South Africa have tended to be project and site focussed. Whilst we argue that LCA/LCE have a definite role to play here too, usage of LCA has been limited to isolated cases in forward-thinking organisations, and LCA methodology has been applied with a somewhat different focus.

As yet there is little incentive in South Africa to use LCA data at a national level, although the South African government has initiated a study to determine whether an environmental labelling scheme, with the use of LCAs, would be beneficial for South Africa [14]. In addition there are no governmental pressures with regard to policies for green procurement and LCAs are, therefore, mainly voluntary and motivated by internal benefits. Recently, there has been an increased demand for LCA data from developed countries that use products exported from South Africa. This external driver will probably result in an increasing number of LCA studies conducted by companies and it is expected that the use of LCAs will increase in a fashion parallel to that of management systems based on the ISO 14001 series of standards.

LCAs have typically been used in the attributional sense to generate an environmental profile of a product or process, in order to identify possible environmental burdens and to support other environmental initiatives, most often the ISO 14001 environmental management systems. In these cases, the capacities of the LCA methodology have been focussed on aspects such as internal waste minimisation, strategic environmental assessment, environmental impact assessment support and environmental reporting. Some of the LCA research and application in South Africa has, however, attempted to cross into consequential modelling, with applications in decision-support [15] and design for the environment [16] (DfE). Some of the applications of LCAs presented in the literature [17], as well as level of use in South African research, are shown in **Table 2.**

3 Limitations and Common Problems

Some of the problems encountered by South African LCA practitioners and researchers relate to the LCA methodology in general and some problems are specific to South Africa.

Data availability and quality is a common problem for the studies done by academia and research institutes. The South African industry shows a general reluctance to provide LCI data, as the benefits of participating in these studies are not apparent. Therefore, few companies make data available in a format that can be used in an LCA, and usually it is time and effort consuming to compile this data. The reluctance of companies to release environmental data is also historical and originates from the high protectionism South African companies enjoyed in the past, especially energy intensive industries, and the economy's mining and primary beneficiation focus. Where LCAs are conducted internally, this problem is not so acute and usually relates to data outside the control of the company.

To overcome the lack of data, South African organisations involved with LCA use different available databases included in the commercial software packages [18], e.g. TEAM,

SimaPro, Gabi3 and PEMS. These databases have been developed overseas and create problems for the LCA practitioner, because data that have been collected elsewhere have to be applied to the South African situation. A margin of error can consequently be introduced between data from different countries and continents owing to different practices, in particular technologies and regulations. Other developing countries are faced with similar problems.

Another major problem, specific to South Africa, is the relevance of the available impact assessment methodologies. The environmental impact categories have been developed for the European situation. Impacts not considered important in the northern hemisphere, are of major importance for this country, especially water resources. Water resources include water quantities available and water quality issues, e.g. water salination. Different levels of impacts on land resources should be considered in the South African context, e.g. soil erosion. Therefore, there is a need to include local environmental priorities and research is underway to develop methods more appropriate for South Africa.

In terms of publishing LCA studies, limited capacity for critical review has been recognised by the LCA community of South Africa. The problem is further exacerbated by currency exchange rates, making review from developed countries expensive. Although in its initial stages, it is hoped that a local formal network or forum will enable growth of the critical reviewing capacity in South Africa.

Other limitations of the LCA methodology that have been dealt with in the literature [19,20] are also applicable to South Africa and include setting system boundaries, linking ambient measurements to the calculated impacts resulting from a specific process or activity, and accidents, incidents, upset process conditions and spills that are not considered as factors in LCA studies.

4 LCA and LCE Activities in South Africa

4.1 Research-focussed LCA activities in South Africa

The South African institutes, academia and industries that have undertaken LCA studies and development are shown in **Table 3**. University researchers have engaged in the development and application of LCA techniques for some time, responding to uniquely South African needs in the resource industries and in relation to water management, and producing graduates skilled in LCA as well as research publications. The CSIR [21] was the first African research institute to invest in the building of a competency in LCA. Its Environmental Process Solutions group has undertaken internal and external LCAs in the packaging, metals and textiles industries. The formal alliance between the CSIR and the University of Pretoria [22] is used to develop the current impact assessment methods further for South Africa through PhD studies at the university. Other developments include non-quantitative streamlined LCAs for developing regions of Africa, specifically with respect to waste management.

In a recent development, the automotive industry of South Africa [23], in conjunction with a local provincial government, is funding a chair in LCE at the University of Pretoria. The chair is required to develop the South African expertise in LCE and specifically in Design-for-Environment (DfE) concepts through research and postgraduate courses in LCA, LCE and Life Cycle Management (LCM). Consultation with LCE expertise from Germany aligns the curricula and research activities of the chair. The focus of the chair is primarily directed towards the automotive and related support industries, involving multi-disciplinary academics.

The University of Natal [24] has concentrated on internal projects at industries as practical case studies. The emphasis of the research has fallen on data collection from process industries for the LCI phase of the case studies and using

Table 3: South African research activities and interactions in the LCA field

Research institutes	LCA activity	LCA interactions
M&Mtek, CSIR	• Consulting and LCA studies • LCIA method development • Application development, especially for waste management • Technical review of LCAs	UP, University of Stuttgart, Fraunhofer-Gesellschaft, Chalmers University of Technology, metallurgical industry, Plastics Federation of South Africa, PwC, CAIA
Universities	**LCA activity**	**LCA interactions**
Pretoria (UP)	• Dedicated chair in LCE • SA default LCI databases • LCIA method development • DfE development • LCM, LCA and LCE masters courses	CSIR, Fraunhofer-Gesellschaft, University of Bayreuth, Chalmers University of Technology, Automotive Industry Development Centre, Centre for Automotive Engineering, PwC
Natal (UN)	• Research case studies, especially in the process and water treatment industry • Data collection methodologies • Impact category development for water salination	Technical University of Denmark, University of Stuttgart, WRC, paper and pulp industry, waste water treatment and water supply industry
Cape Town (UCT)	• Research focussing on LCA opportunities in the resource (metallurgical, energy and fuels) industries • Integration of LCA with process design methodologies • Decision support methodologies • Impact category studies, e.g. water salinity equivalence factors	SETAC, University of Sydney, University of Surrey, US EPA, power utility, metallurgical industry, used oil recycling NPO, sugar industry
Witwatersrand (Wits)	• Comparative studies and evaluations	Plastics Federation of South Africa, UP, UN, UCT

available LCIA procedures. A key area of interest of the Pollution Research Group at the university is wastewater treatment. The group has consequently also undertaken the development of an impact category specifically relating to water quality, i.e. water salination. With respect to the LCA field, the group has a strong alliance with the Technical University of Denmark and the University of Stuttgart.

Researchers at the University of Cape Town [25] have studied the use of LCA in the context of process industry design since the early 1990s. Recent work has focussed on LCA as an evaluation and management decision support tool, especially in the resource industries (metals, power, agricultural produce, water, waste) through a number of MSc and PhD studies, and on the integration of LCA into process systems design [26]. Exploiting the similarity of the resource industries in South Africa and Australia, the group has a strong alliance with the Centre for Risk, Environment, Systems Technology and Analysis (CRESTA) at the University of Sydney, Australia that specialises in the application of life cycle thinking in decision support.

4.2 Involvement of South African industries and government in LCA

Certain sectors of the South African industry have been active in the area of LCA for the last five years. This is largely due to ISO 14000 environmental management improvement strategies and involvement in the responsible care endeavours of the Chemical and Allied Industries' Association (CAIA) [27], specifically of companies with a product stewardship policy. However, there is as yet no agreement on best practicable LCA procedures for South African industries, and the exchange of data is inadequate [28]. South African industries use LCAs internally and there is little incentive to publish the results. The levels of internal competence differ significantly, and interaction and cooperation with research institutes and academia are considered important.

As at the beginning of 2002 the involvement, albeit limited, of South African government in LCA-type projects is threefold. Firstly, although referring to the LCA tool in its integrated pollution and waste management white paper [29], the South African Department of Environmental Affairs and Tourism (DEAT) has not initiated or funded any concrete projects using this tool. Secondly, the Water Research Commission (WRC), a statutory organisation that reports to the South African Department of Water Affairs and Forestry (DWAF), is currently financing and supporting LCA studies although DWAF itself has not actively commissioned LCA studies. Thirdly, the South African Department of Trade and Industry (DTI) undertook during 2001 to use the LCA approach to assess the criteria for an eco-label scheme [14]. With respect to the acceptance of the LCA procedure into the South African environmental management framework, the ISO 14040 and 14041 standards were approved as South African standard codes of practice in 1998 and 1999 respectively [30,31]. ISO 14042 and 14043 standards are not incorporated to date.

4.3 Current LCA information sharing in South Africa

The information contained in this article is the result of interactions between LCA practitioners in South Africa. The exchange of information is primarily due to a South African LCA forum or network that is in the process of being established. The Pollution Research Group of the University of Natal initiated the forum in December 1999 with support from the CSIR and three other industries, *viz.* Eskom, Impala Platinum and Sasol. A second meeting, held in October 2001, included the University of Cape Town. However, the structure of the network and interactions between current and potential other participants are not formalised.

5 The Future of LCA in South Africa

LCA practitioners expect an increase in the number of LCA studies undertaken in South Africa. The creation of the South African LCA network is a step forward in finding solutions to the problems specific to South Africa. Such solutions would imply specific adaptations to the methodology of developed countries, or even the development of new procedures. The driving forces for LCA studies will continue to be internal (to companies) and external (from importers in Europe and the USA or international owners). It is expected that internal company initiatives will grow, as they realise the economic implications of the environmental burdens of products and services. Environmental LCA information is required in order to access export markets in most of the developed countries. As stated in literature [32], if South African products *are to be marketed internationally and specifically exported to first world countries, LCAs need to be performed as prescribed, for example, by EU legislation, the international customer, etc.*

The external demand for life cycle inventory data from South Africa is also increasing, since South Africa is a major exporter of raw materials, especially minerals. These materials enter different cycles of production in countries where LCAs of products are required. As a result there will be an increase in the number of LCA studies done on the extraction and processing of various export minerals in South Africa [32]. This in turn will stimulate the need for LCA studies on the inputs (electricity, water, cement, etc.) to these primary export-orientated industries.

In order to address the foreseen demand in LCA expertise, South African tertiary institutions are expanding their courses and research in the field. Further collaboration between researchers and industries involved in LCAs will considerably benefit the growth of LCA and LCE in South Africa.

6 Conclusions

In conclusion, research activities in South Africa are addressing the limitations and problems of LCA and LCE methodologies in the South African context. The research was originally focussed on the important resource processing industries and the treatment of waste streams. However, in line with the changes in economic activities, developments

are taking place in other manufacturing sectors. The participation of industry and governmental departments is still limited and the national drivers for LCA studies are less by number and by variation in South Africa compared to developed countries, resulting in a limited number of applications. However, the increasing environmental pressure on exported products is expected to expand the application of LCAs and LCE in South Africa considerably.

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