Improving the Environmental Performance of Small and Medium-Sized Manufacturing Enterprises in South Africa

Opportunities for Co-operative Approaches?

Final Project Report

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Executive Summary

Rationale:

This project has, as its express aim, the desire to explore the structural, operational and institutional impediments to the improvement of the environmental performance of small and medium scale enterprises (SMEs), which have been identified as strategic players in the economic development of Southern Africa. SMEs are seen to hold the key to the creation of a vibrant manufacturing culture through employment generation, entrepreneurship and product diversification. At the same time, it is acknowledged that, though their individual contributions to environmental degradation may well be small, as an industrial collective their impact is significant.

Any strategy aimed at improving the environmental performance of SMEs needs to start by recognising that industries within this group may lack the necessary technical expertise, capital availability and management perspective to effect constructive change by themselves. The overriding question is how to overcome these constraints to improved performance in ways which are cost-effective and give due recognition to the need of SMEs to maintain maximum flexibility in their operations in response to changing market forces.

To date, the environmental performance of Southern African industry has been assessed mainly from the standpoint of the production cycle only. When industries form part of a large supply chain, environmental criteria are often set by the larger companies in this chain. When this occurs, SMEs in the chain are constrained in their operation by factors over which they feel they can exercise little control. What is needed is a strategy which helps SMEs position themselves as indispensable links in this supply chain by being “responsive to complex consumer demands in a flexible way, producing products which exactly fit customer requirements whilst retaining a degree of specialisation”. This requires an operational model for SMEs in which the integration of quality management, environmental management and flexible specialisation is optimised. Whilst SMEs may not benefit from “economies of scale”, they certainly enjoy “economies of scope”. This project seeks to capitalise on this potential.

It is our basic premise that interactions of the societal-industrial system with the environment extend beyond the production cycle; upstream to all aspects of resource extraction, and downstream, through all intermediate use and re-use stages, to ultimate disposal. Implicit in this expanded definition is a requirement to optimise the total materials cycle, given the continued economic, technological and cultural evolution associated with the development of the SME sector. It is just this “expanded” definition of the industrial system which provides the platform from which to launch, and help promote, innovative business practice to help ensure true business “sustainability”, both in economic and environmental terms.

There is an incontrovertible link between the concepts of “sustainable development” and “clean technology”. The first embodies the goals of effective and equitable resource management whilst ensuring environmental well being and economic advantage, through, amongst other objectives, the promotion of industrial competitiveness. Clean technology has the broad goal of defining industrial practice in such a way that the goods and services which society values are produced with minimal environmental impact. This goes beyond the application of “clean up” technology for pollution control. Fundamentally, it entails a shift in emphasis; to see production as a sub-set of the overall material economy, and not an inflexible entity whose scope is defined by the perimeter boundary of any industrial / manufacturing activity. There is a need to position individual firms within their supply chain network, and to use such a model to strive for overall improvements in system performance in a way which assures firms of gains in environmental and economic performance i.e. improved eco-efficiency. Industrialists who choose to follow this strategy will be appraised of the inter-relationships which exist within the material economy, and can position themselves to respond dynamically to changing environmental pressures, thus ensuring their economic survival in the long term - hence the concept of “business sustainability”. This is no more true than in the case of SMEs.

Methodology:

This project is concerned with optimising the economic and environmental performance of SME industries by exploiting the positive synergism and interdependencies which exist within the sector. The basis of this approach is the recognition of the existence of operational networks to which individual firms belong, and through which they maintain their competitive advantage. These networks include “intra-sectoral” linkages e.g. financial - common markets, and “inter-sectoral” linkages e.g. the material supply chain. At the same time it is recognised that individual firms within a given sub sector may lack the necessary technical expertise, capital availability and management perspective to effect constructive change in their overall performance by themselves. This raises the need for a third type of network - one of support. These networks may enjoy some spatial dependence, but equally may be linked only through material and capital flows.

The project focused on two critical SME sub-sectors in South Africa – those of textiles manufacture and metal finishing. Five companies from each sub-sector were selected to participate in the project. The criteria for their selection included their scale, their eagerness to improve their environmental performance, and other measures relating to the degree to which they were "networked" with their suppliers, customers, and trade-support organisations. For each company, a detailed assessment was undertaken, generating comprehensive information sets, not only on their environmental performance, but also their economic viability, management culture and technical and resource constraints. This information base was then interpreted in terms of the following key objectives:

1. To construct and validate an experimental Industrial Ecology model of the two sub-sectors, composed of two inter-related components - one dealing with economic interactions, and one dealing with mass and energy flows within, and among firms.
2. To apply the model in order to assess the potential for eco-efficient solutions to be introduced at both the firm level and system wide.
3. Based on the results of model simulations, to identify a range of possible interventions to deal with environmental issues in the two sub-sectors, and to design possible demonstration projects to be implemented with individual firms, or groups of firms.
4. To draw a series of conclusions about the applicability of the industrial ecology model to the sub-sectors under study, and to SMEs more generally.
5. To diffuse the results of the research both in academic circles and to industry and public sector audiences.

As the project evolved, it became clear that the above objectives were perhaps too ambitious. Difficulties in getting access to the necessary information for model development lay at the heart of this observation. Additionally, whilst the participating companies were eager to improve their existing operations, and could appreciate the logic of the project approach, their attention was very much focussed on their own production activity, and less so on their position within any given network.

As a consequence of this realisation, project objectives were moderated to read thus:

- To study, in specific companies, the willingness, intent and capacity of management to initiate and apply preventative practices for environmental management
- To investigate company economic performance as a constraint to improved environmental performance, and to characterise the economic situation of our test sectors at large in order to extrapolate findings into the economy as a whole.
- To characterise the significance of any individual company's position within a larger production system, as a determinant for that company's ability to effect improvement in its own operations, and in the system at large.

These revised objectives retain the intent of the original ones, whilst allowing for a more reasonable (and realistic) view of the selected sub sectors.

<u>Main Findings:</u>

1. All companies participated in a first-order waste minimisation assessment exercise, covering their full operations. Improvement opportunities existed for all companies, all with a good chance for successful implementation. This "across the board" existence of improvement potentials verified a basic premise of the entire research project, *viz.* that there is a need for better environmental management within the SME sector, at least as far as these two sub-sectors are representative.
2. The majority of identified improvement opportunities within individual companies would need, or would benefit from, co-operation between the target company, and what we term "network partners". These partners were typically the suppliers of technology and raw materials, and, to a lesser extent, the target company's customer base. This confirms the value of the network approach to environmental improvement, whilst also hinting (strongly) for the adoption of the practice of "extended producer responsibility" by the SME sector.
3. The project was able to demonstrate a methodology for documenting the relationship between target companies and their network partners. In particular, the project developed (and demonstrated) a formalised

procedure to search within company networks for opportunities to improve the performance of a given target company.

4. The ability of individual SME companies to avail themselves of environmental improvement opportunities is a strong function of company values, management intent, and company capacity. For symbiotic functioning to become a feature of the SME sector, attention needs to be devoted to
   (a) nurturing a company sense of responsibility towards the environment
   (b) better diffusion of cleaner production “know how”
   (c) development of human resources capacity
   (d) building capacity for innovative adaptation of technologies
5. In many respects, the constraints identified in (4) above could be addressed by better access to technology financing for each of the companies surveyed, and thus, we believe, to all SME members.
6. The project highlighted the need and opportunity for co-operative approaches to improving environmental performance in these sub-sectors. There are a number of key role-players here: suppliers who practice the “extended producer responsibility” identified above, industry consultants who can work collaboratively rather then prescriptively, and policy makers to provide the enabling framework through which these constructive interventions can be carried out.

Policy Implications

It was an explicit objective of this project to assess the degree to which the lessons learnt through the individual case studies could be generalised to the SME sector as a whole, thereby guiding policy development. Whilst not wishing to downplay the limitations of the project analysis, it is possible to extrapolate many of its findings.

For one, the fact that similar trends were observed in both sub-sectors, and similar network model structures could be developed for each, there is good reason to think that this approach has general applicability for the SME sector.

Consequently, we propose the following recommendations for policy development in support of enhanced environmental performance by SMEs.

1. Attention should be paid to promoting the concept of extended producer responsibility for suppliers within SME networks. In terms of chemical purchases particularly, this should focus on their use efficiency and waste management requirements.
2. Good housekeeping practices are seen to afford many opportunities for improving environmental performance. Whilst corporate culture is important here, so too is the development of mechanisms by which to disseminate appropriate information. To this end, we advocate a mixed approach - covering better enforcement of Occupational Health and Safety legislation, and provision of information and advice on Cleaner Production (through direct Government support, or via an appropriate National Centre). It is recognised that, whilst the success of such centres, on a world scale, has been mixed, most of these were implemented from a narrow philosophical viewpoint some 10 years ago, and much has been learnt since (including via this project) on where to place emphasis.
3. Better access to development capital is necessary for SMEs who are serious about improving their environmental performance. We recommend innovative funding / loan schemes linked to indicators of improved environmental performance. One particular observation we would make is that many SMEs are seemingly ‘locked out’ of access to venture capital, because they do not comply with the edict for empowerment of businesses with Black ownership.
4. From our observation that even those companies with access to development capital are slow at investing in Cleaner Technologies, we recommend that mechanisms be developed to promote the access of SMEs to new technologies and support skills. Whilst the concept of a National Cleaner Production centre is one way forward, other innovative approaches exist too, and we would encourage due consideration of these.

Concluding Statement:

The results of this project go some way to suggesting strategies for the SME sector to improve its economic competitiveness, in large part, by striving for improvements in environmental performance. As such it should have value both as a management tool for firm-level operators within the same network, and as a strategic policy formulation tool to ensure long term business “sustainability”. The network examples explored here might well lead to the establishment of similar networks elsewhere in Southern Africa, thereby giving some direction to the overall upliftment of the SME sector in the region.

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1 Introduction

1.1 Background

This document is the final report on a three-and-a-half year research project which set out to investigate the topic of Industrial Symbiosis amongst small and medium enterprises (SMEs) in the manufacturing sector of the South African economy. Industrial Symbiosis is a concept derived from the metaphor of Industrial Ecology. It proposes, in essence, that business enterprises can improve the overall efficiency of material and energy utilisation by establishing symbiotic relationships mirroring those found in nature. Such efficiency improvements would, in turn, lower the adverse impact of industrial activity on the environment, and would thus contribute to the aim of more sustainable industries. Further, by their very nature of gains in efficiency, such improvements would also be expected to yield tangible returns on the employment of resources such as capital and labour needed to initiate and establish the symbiotic relationship.

This introductory chapter of the report discusses the context in which the project was carried out, paying attention to the significance of small and medium enterprises in the South African economy, and reviewing in some more detail the concept of Industrial Symbiosis. It further presents the approach taken to the research, and concludes with a guide to contents of the six main chapters of the report.

1.2 Environmental and Economic Significance of SMEs in South Africa

The development of the small business sector is seen as vital to the South African economy because of the opportunities it offers for growth and for the creation of employment. It also provides a means for redressing the economic imbalances which exist as a result of past policies, where an equitable distribution of the benefits of economic growth is now required. Statistics show that the highest degree of economic activity amongst black entrepreneurs occurs at the micro end of the spectrum and it is therefore not surprising that many of the programmes designed to assist the small business sector are aimed specifically at the informal sector, in an attempt to raise the level of business of such enterprises and ultimately incorporate them into the formal sector.

The legislative framework has, in the past, largely favoured the development of large companies. SMEs, on the other hand have traditionally not enjoyed the same support measures as have large enterprises. One of the most outstanding features to underline this observation is the difficulty which many smaller, independent enterprises experience in raising finance for capital expansion. Considering that SMEs form 41.1 % of all South African enterprises and provide 34.6 % of all jobs (DTI, 1998a), they are indeed a vitally important part of the economy, and need to be supported. Using the wider definition of small business (i.e. including micro enterprises), SMMEs form 59.2 % of all enterprises, and employ 41.6 % of the employed workforce. However, the past few years have seen a change in focus, with more emphasis being placed on small business development and support.

There exists, however, a concern that in the endeavours to create wealth and so redress the imbalances of the past, too little attention may be given to the ecological sustainability of such development, as called for in the Bill of Rights. The most direct impact of economic activity is of course felt in the primary and in the manufacturing sectors of the economy. In this project the focus has been on the manufacturing sector, in which formally recognised small and medium-sized enterprises play an important role. Whereas large corporations in this (and indeed any other) sector generally have both the motivation (resulting from their high visibility) and the resources to address environmental management, less evidence is found that this is the case amongst SMEs. The Industrial Symbiosis project was thus targeted at SMEs in the manufacturing sector, and had no intentions to address micro enterprises, nor companies in the informal sector. A South African definition of SMEs is provided in Appendix 1.

1.3 Industry and Environmental Management in South Africa

When the Industrial Symbiosis project was conceived, attempts to improve environmental performance in South African industry were largely reactive, often aiming to meet concentration-based emission standards, albeit at times on the basis of more stringent norms applicable in other countries. The focus generally was (and still is) on single factories and production facilities, with narrowly defined system boundaries. Environmental Impact Assessments, then already conducted regularly, and since September 1998 called for by law, whilst designed to identify alternatives, only address new projects and this with a limited capacity for the identification of systemic improvement options. The Industrial Environmental Forum had published a 10 point code of conduct largely based on self regulation and on good environmental reporting.

Against this background on the one hand, and the positive results reported internationally concerning the development and application of preventative environmental management strategies and tools on the other, a clear opportunity existed for an investigation into the capacity for improved environmental management in South African industry, and in particular, for the reasons cited above, in the SME sector. This was the starting point for this project.

Two imperatives upon which the investigation was based were (i) that a larger view of production systems would have to be taken, and (ii) that the capacity for the application of preventative or proactive means of environmental management, as opposed to reactive means, would be focussed on. At the same time, the theory of Industrial Ecology had been sufficiently advanced (e.g. Graedel and Allenby, 1995; Allenby and Richards, 1994) to inform a research project with the above two imperatives. This view of the economy essentially states that industrial activity may be seen an extension of ecological processes, and that it should therefore benefit if it were structured according to the same rules which make natural processes so efficient.

Drawing from these developments in strategic environmental thinking, and given that the investigation aimed to look at the performance of larger production systems whilst maintaining the focus on smaller and medium-sized enterprises contained therein, the project at its outset proposed to study symbiotic behaviour as a specific means to advance environmental performance.

1.4 Symbiotic Behaviour and its Place in Industrial Ecology

The theory of Industrial Ecology proposes that much can be learned concerning the optimisation of industrial systems by studying the behaviour of natural ecosystems. If this is indeed the case, then parallels can be drawn between a company on the one hand, and an individual organism on the other. Survival and well-being of the individual enterprise would then depend both on its habitat (surroundings), and on its inherent characteristics (which it shares with other similar individuals, its “species”); with the combined influence of the two making the individual unique.

Such sentiment is echoed by recent management theories based on ecosystem thinking, e.g. Lewin (1997) who proposes that a company will increase its chances of survival by realising its position and function in its network. In contrast to a focus on the individual, Industrial Ecology would however be interested in the factors which govern the relative abundance of different species, as well as the ability of ecosystems, being the combination of habitat and species, to maintain life-supporting conditions and to assimilate wastes.

Such analogies can be developed and interpreted, and shortcomings would evidently emerge. (Individual companies, e.g. can merge, which may enhance the success of both the individual and the species through a reduction in its numbers, quite opposite to what is found in nature). An important lesson may however be drawn for an application of the concept of Industrial Ecology to the SME sector: the systems analyst should gather and interpret data both on the characteristics of certain types of companies (possibly by looking at several individuals) and on the surroundings in which the company operates.

This approach was followed in the study presented in this Final Report, i.e. data was gathered both on the characteristics and performance of the companies studied (chapters 4-6), and on the network in which they operate (chapter 7).

Co-operation is found in nature both between individuals of one species, and between those of different species, the latter termed symbiosis. Both probably result from an inherent characteristic of the species. Both mechanisms are also well established in industrial ecosystems, with industry associations representing collaboration between individuals of a similar make-up (such collaboration may however be limited by legislation, e.g. “hunting in packs” being disallowed by anti-trust laws), and examples of different types of companies sustaining each other also being well-known. It was this latter mechanism which was defined to be a target area for the research presented here, in the belief that increased symbiotic behaviour would result in two desired outcomes: (i) increased chance of survival and well-being for individual companies, and (ii) more efficient production systems generating less waste and pollution; the combination of the two outcomes being embodied in the concept of “eco-efficiency”. Again, with such objectives in mind, it was important that the study focus as much on the inherent characteristics of types of companies (“species”) which would allow them to enter symbiotic relationships, as on the opportunities in the environments of individual enterprises which would allow those characteristics to be developed and utilised.

1.5 Objectives of the Research Project

As already mentioned in section 1.3 above, the main objective of the Industrial Symbiosis project was to investigate the capacity amongst SMEs in the South African manufacturing sector to improve their environmental performance, as well as that of the production systems of which they form part. This main objective was to be achieved by developing a flow-based model of SME manufacturing, which would allow systematic optimisation of production activity to be investigated. By implication, a second main objective of the project was to make policy recommendations to help improve eco-efficiency amongst South African SMEs.

Further, an imperative for the investigation was to focus on the capacity for environmentally preventative, or proactive, behaviour. A specific means of such preventative behaviour was seen to lie in the metaphor of Industrial Symbiosis, as discussed above. This made particular sense in the SME sector, as almost by their nature, it could be expected that capacity to devote to environmental matters would be limited, and that joint initiatives would thus seem to be a logical way to overcome limitations and to harness opportunities.

Specific objectives for the project were formulated as follows:

1. To generate data on economic and physical flows within two SME sub-sectors (textiles and metal finishing), based on collection of available sub-sectoral information, and through an iterative process of data gathering. Five firms in each sub-sector were to be used as case studies.
2. Based on these data, to construct and validate an experimental Industrial Ecology model of the two sub-sectors, composed of two inter-related components, one dealing with economic interactions, and one dealing with mass and energy flows within, and among firms. Waste generation and management evaluation were to feature prominently in this latter component.
3. To apply the model in order to assess the potential for eco-efficient solutions to be introduced both at the firm level and system-wide.
4. Based on the results of model simulations, to identify a range of possible interventions to deal with environmental issues in the two sub-sectors, and to design possible demonstration projects to be implemented with individual firms, or groups of firms.
5. To draw a series of conclusions about the applicability of the industrial ecology model to the sub-sectors under study, and to SMEs more generally.
6. To diffuse the results of the research both in academic circles and to industry and public sector audiences.

As the project developed, it became clear that some of the objectives had to be modified. Whilst qualitative information on the selected manufacturing sub-sectors could be sourced (see chapters 2 and 3), quantitative data on sub-sectoral economic and physical flows necessary to build the two-component model envisaged under point 2, above, could not be collated. Instead, significant attention was focussed on the selected case study companies, where quantitative data was collected both for physical resource flows, and on the associated financial flows (all through Waste Minimisation Assessments). Furthermore, in accordance with the dual Industrial Ecology focus discussed in section 1.4 above (“species characteristics”, and “habitat”) the objectives were refined to include collection and interpretation of data on Management in each company, and an analysis of the networks in which the companies operate. Lastly, borrowing once more from natural systems, it was hypothesised that the health (here economic) of an individual would also be an important factor determining to what extent such an individual could function in its “eco-system”. An additional objective was thus to gather and interpret data on the economic health (to be defined in chapter 6) of the case-study companies. These new objectives read as follows:

i. to study, in specific companies, the willingness, intent and capacity of management to initiate and apply environmentally preventative behaviour;
ii. to investigate the effect of the economic situation of particular companies as a factor influencing their ability to improve environmental performance, and to characterise the economic situation of industry sectors at large in order to extrapolate findings into the economy as a whole; and

iii. to characterise the significance of position of a company in a larger production system as a determinant for that company's ability to effect improvement in its own operation and in the system at large.

1.6 Research Approach and Project History

1.6.1 Project structure and organisation

The project was devised as a co-operative venture between a number of South African institutions, these being:

- Department of Chemical Engineering, University of Cape Town
- Development Policy Research Unit, Science and Technology Policy Research Center, University of Cape Town
- Pollution Research Group, Department of Chemical Engineering, University of Natal,
- African Environmental Solutions (Pty) Ltd., Cape Town; and later Gibb-Law Africa, Consulting Engineers (Pty) Ltd; this resulting from changes at African Environmental Solutions.

The lead institution was the Department of Chemical Engineering at the University of Cape Town. The main project sponsor was the Canadian International Development Research Centre (IDRC). As of early 1999, the core project team was housed at Gibb-Law Africa in Cape Town, with project meetings taking place regularly every two weeks.

In the three and a half years of the project, 27 people contributed to or advised on the research project. A full list of all contributors can be found in Appendix 3. There were nine postgraduate students involved in or associated with the project: seven registered for Masters degrees, two for a PhD. To date, no degrees have been awarded, three MSc degrees are expected for December 2000, one PhD and three MSc for 2001; one MSc and one PhD de-registered. Six third year graduate chemical engineering students have done their vacation training in case-study companies in the project between November 1997 and March 1998. Four European exchange students (from Sweden, Holland and Germany) spent between 4 and 6 months each doing research in the project.

1.6.2 Selection of the case-study companies

As mentioned in section 1.5 above, the specific objectives of the project required that research be conducted within selected case-study companies, representative of SMEs in the South African manufacturing sector. Two manufacturing sub-sectors, which had in an earlier study been identified as particularly polluting (EMG, 1993), viz. textiles and metal finishing, were chosen to focus on. It was intended to select five smaller or medium-sized enterprises within each sub-sector in order to collect company-specific data. In selecting these enterprises, the following criteria were set:

1. preferably has clear environmental problems;
2. more than 30 but less than 300 employees;
3. member of an industry organisation;
4. not too diverse a range of products (e.g. preferably 1 metal for plating);
5. has (seriously thought about) an ISO-accredited management system;
6. preferably already has some form of data gathering or measuring practice in place.

If possible we tried to include companies that had something in common with the other companies, be it either a common market, a direct supply or service relationship, similar processes, similar waste problems or similar raw materials.

Securing companies to participate in the research project was cumbersome. In general we tried to apply the above criteria, but as time progressed, a number of companies meeting at least half of the criteria were signed on.

Names and addresses of companies to be approached were obtained in one of two ways:
1. Via address lists from yellow pages, industry associations, etc.
2. Via people who knew both the project and the company

- one contact exploited here were relevant departments at the Cape Metropolitan Council (local government);
- personal contacts of (friends of) project team members were used;
- in two cases, companies were suggested by those already signed on.

Ultimately, the target of five companies from each of the two sub-sectors was met and, except for one enterprise in the textile finishing sector, all data gathering assessments as per the objectives in section 1.5 above, could be completed in all companies. A description of the companies that participated in the project is given in Table 1.1.

Table 1-1: A description of the companies that participated in the project

company	employees	ownership	Production processes	SME criteria		
				≤ 250 employees	Indepen-dantly owned	SME ? (Y/N)
M1	20	Owner MD	Powder coating	Y	Y	Y
M2	40	External owner(s)	Galvanising	Y	Y	Y
M3	300	Part of listed group	Hardchroming, manufacturing	N	N	N
M4	250	Part of listed group	Electroplating	Y	N	N
M5	30	Owner MD	Hardchroming	Y	Y	Y
T1	110	External owner(s)	Textile printing	Y	Y	Y
T2	200	Owner MD	Textile printing	Y	Y	Y
T3	350	External owner(s)	Design, dyeing and CMT	N	N	N
T4	130	Part of listed group	Non wovens manufacturing	Y	N	N
T5	1300	Part of listed group	Spinning, weaving and dyeing	N	N	N

1.6.3 Major events in the project's history

In the course of the project, two progress reports were issued, and two workshops were organised to gather and evaluate information, and disseminate intermediate results. Beyond that, papers were presented at two international conferences, and input was offered to the formulation of DANCED's Metal Finishing Industry Cleaner Production Project, as well as the National Waste Management Strategy which was finalised in late 1999. The following list summarises these events.

- First Progress Report, February 1998.
- First Industrial Symbiosis Workshop, 16 March 1998.
- Second Progress Report, February 1999.
- Paper delivered by M.Sc. student D. van Beers at the International Conference on Industrial Ecology and Sustainability, 22-25 September 1999, Troyes, France.
- Input to the NWMS at a stakeholder meeting, October 1999.
- Second Industrial Symbiosis Workshop, 29 November 1999.
- Presentation of 2 papers at WasteCon 2000, Somerset West, South Africa, 4-7 September 2000.

1.6.4 Overview of project outputs

Besides the two progress reports mentioned above, and the company-specific assessments (waste minimisation, network maps, management, economic health) issued to the companies only and kept confidential, the project has to date resulted in the following generally available written outputs:

- Industrial Symbiosis Workshop, Notes, 16 March 1998.
- 1st Workshop on Industrial Symbiosis : Concise Workshop Report, Dept. of Chemical Engineering, UCT.

- “Development of a Method for the Identification of Eco-Efficient Improvements in the Industrial Networks of SMEs”, D van Beers, B Kothuis, H von Blottnitz and J Raimondo, Proceedings of the International Conference on Industrial Ecology and Sustainability, 22-25 September 1999, Troyes, France.
- The Second Industrial Symbiosis Workshop, Notes, 29 November 1999, Dept. of Chemical Engineering, University of Cape Town.
- The Second Industrial Symbiosis Workshop: Workshop Report, Dept. of Chemical Engineering, University of Cape Town, December 1999.
- “Waste Minimisation In The Metal Finishing Industry; European Study Tour June/July 1999”, C Jänisch, Department of Chemical Engineering, University of Cape Town, December 1999.
- Overview and Economic Review of the South African Metal-Finishing Industry, Eckart Naumann, Department of Chemical Engineering / School of Economics, University of Cape Town, March 2000.
- Overview and Economic Review of the South African Textile Industry, Eckart Naumann, Department of Chemical Engineering / School of Economics, University of Cape Town, March 2000.
- “On the real costs of waste treatment: the case of an effluent treatment plant in the metal finishing industry”, B. Kothuis and H. von Blottnitz, to be presented at and published in the proceedings of WasteCon 2000, 5-7 September 2000, Cape Town
- “Cleaner Production as a tool to minimise the volumes of solid waste arising in small and medium enterprises in the South African Metal Finishing industries”, C. Jänisch, B. Kothuis and H. von Blottnitz, to be presented at and published in the proceedings of WasteCon 2000, 5-7 September 2000, Cape Town

Further to the already published information, it is intended to publish the most striking case studies and success stories of Cleaner Production encountered during this project in the form of one page fact-sheets. A sponsor is needed.

Also, by year-end 2000, two M.Sc. theses are expected to be published at UCT; these will be by Claire Jänisch and Dick van Beers, and will be available through the UCT libraries. The respective titles are “An Assessment of the Potential for Waste Minimisation in Small and Medium Enterprises in the Metal Finishing Industry in South Africa”, and “Identification of Eco-efficient Improvement Opportunities in the Industrial Networks of Small and Medium-sized Enterprises”.

1.7 Structure of the Report

As was identified above, the study focussed on two sub-sectors of South African manufacturing, viz. Textiles and Metal Finishing. Chapters 2 and 3 of this report are dedicated to these two industrial sectors, describing the processes generally used, key economic indicators, environmental profiles, and thus the challenges and opportunities faced by the industry. These chapters are based on longer reports compiled in the UCT School of Economics (Naumann 2000a and 2000b), and serve to sketch the background for the ensuing discussion of results as abstracted from the case study investigations. Full versions of the sector studies are available upon request.

The next three chapters describe the case studies, i.e. the company-level improvement assessments. These were: firstly the waste minimisation assessments (chapter 4), secondly the characterisation of management (chapter 5), and thirdly the investigation into company economic health (chapter 6), as a determinant for capacity to improve environmental performance, be it through symbiotic behaviour or otherwise.

The last section of the report presents the analysis of the networks of which the case study companies form part. The methods developed and the insights gained are presented and discussed. This is followed by a concluding chapter, in which a number of recommendations for further study and for policy intervention are presented.

2 The Textile Industry in South Africa

The textile industry was one of the two industry sectors investigated in this project. The reason for this on the one hand was that the textile sector had been identified in previous studies as being the 3rd most polluting industry sector in South African manufacturing, after the mining and chemicals sectors (EMG, 1993), and on the other that it is characterised by a strong presence of SMEs (see Table 2-1). This chapter is largely based on work by Naumann (2000b).

Table 2-1: Significance of SMMEs in the South African textile sector

Textile sector		**SMMEs in the sector**	
Total no of firms	701	% of total number of textile firms	74 %
Employment offered	77,200	% of total employment	37 %
Value of sales (R million)	9,200	% of total value of sales	25 %

2.1 Broad Overview of the South African Textile Industry

The textile industry is responsible for the manufacture of a diverse range of textile products, and is part of the greater manufacturing sector of the economy. The South African textile industry produces products from natural (cotton, wool, mohair, bast) and synthetic (polyester, nylon, acrylic, polypropylene) fibres, yarns (homogenous and heterogeneous blends), fabrics, household textiles (curtains, upholstery, bed-linen) technical textiles (geo-textiles, webbing etc) and medical textiles (abdominal swabs, bandages, surgical gowns etc. Many of these products are in turn used in the manufacture of clothing. Textile industry statistics used in this chapter refer solely to textiles, and not the greater clothing sector.

The South African market demand for textiles is very unique, and encompasses developed, developing and undeveloped country characteristics. For example, while the local market generally demands a very diversified range of textiles, the quantities are small by international (developed country) standards – usually totalling no more than a third of the 'sophisticated world' countries' consumption.

Due to the relative ease with which the textile industry can be established, this industry has become an important manufacturing cornerstone in many developing countries. The industry in general uses significant amounts of labour, a resource that developing countries generally have an abundant supply of. The industry is also important as a consumer of materials and services, and many upstream and downstream industries rely on the textile industry directly or indirectly. The textile industry thus often serves as a cause and catalyst for other industrial development. It should be noted, though, that low-cost labour per se is an insufficient variable to guarantee a comparative advantage in this sector, as low productivity (as is the general case in South Africa) often negates any benefits of low-priced labour.

The textile industry in South Africa is, in terms of output and enterprise size, relatively polarised. On the one hand, a number of very large textile manufacturers exist (predominately in Kwazulu-Natal), on the other hand, a large number of typically SME-sized enterprises exist, although their growth rates have been curtailed by a number of inherent limitations and difficulties.

It was recognised in the 1950's that in order to protect South Africa's textile industry with all its unique characteristics (not least of which was its status of being an important provider of jobs), the government had to introduce protectionist measures. These mainly worked in the short run and many of these protectionist measures are in the process of being dismantled in line with international free trade agreements.

Consistent with the government's *Growth, Employment and Redistribution* (GEAR) macroeconomic strategy of the 1990's, the promotion of the SME sector is an important cornerstone of employment creation and income generation. A major effort will be made by the government to deliver on policies (and promises) to promote small and medium business development. According to a 1995 report (Dyegest), 74 % of the total number of textile firms could be classified as Small, Medium and Micro enterprises (SMME). It would appear likely that the figures for *SMEs* are similar. Legislation is being introduced that could see an increased focus on (financial and other) support for Small and Medium Sized Enterprises (SMEs).

The potential downside of a greater focus on SMEs, at least from an environmental view point, is that SMEs often create a (cumulative) significant problem with regards to waste management (Gilfillan, 1997), being difficult to police and often unaware of the environmental impact of their operations.

2.2 Common Processes Used in the Textile Industry

There are various steps used by the textile industry to process the raw materials and transform them into finished textiles. The main raw materials used in the manufacture of textiles are cotton, wool and synthetic materials. Some of the steps required are unique to certain input materials used, while other processes are used irrespective of the fibre type. The following are the main processes used:

- ***Blending*** is a mechanical process where fibres from different bales of cotton or wool are mixed to get the right mixture quality.
- ***Spinning*** is a mechanical process whereby fibres are transformed into yarn and a twist is introduced. This makes them ready for the further process steps of knitting and weaving.
- ***Sizing*** involves the coating of yarn to lend it protection against excessive abrasive action in the weaving process, as well as removing some of the yarn hairiness.
- ***Weaving*** is a dry process (which utilises high humidity conditions to reduce the possibility of breakage and tearing of the yarns).
- ***Knitting*** is a dry process (which makes use of oils to reduce the wear-and –tear during the process. These subsequently need to be removed).
- ***Desizing*** involves the removal of the sizing agent that was applied, and is usually carried out after the weaving stage.
- ***Scouring*** is a process whereby the inherent impurities found in the raw materials are removed. The different fibres are scoured in different ways; cotton being scoured with hot sodium hydroxide solutions and detergents, wool using sodium carbonate and detergents, and synthetic fibres are scoured in a mild to strong alkaline solution.
- ***Singeing*** involves removing the surface hairiness from a woven fabric, thereby enhancing its feel and appearance.
- ***Bleaching*** is a process whereby oxidising agents (such as hydrogen peroxide) are used to reduce or remove the natural colour of the fabric.
- ***Mercerising*** is a process whereby concentrated sodium hydroxide solution is applied to cotton fibre to increase its tear strength, sheen and dyeability, after which the fibre is rinsed extensively.
- ***Printing*** involves the application of dyestuffs to the fabric surface, after which it is dried, fixed and the residual washed off.
- ***Finishing*** is the last step in the textiles production process, and involves various processes to enhance the visual appearance of the material, handling characteristics, stain resistance, softening and other special properties.

In summary, the processes that are used in the textiles industry can be categorised by the actions that are performed on the textile materials, as shown in Table 2-2.

Table 2-2 : Processes used in the textile industry

PRINCIPLE	PROCESSES
processes that make loose fibre bales into more structured forms (the structures being for example non-wovens or yarns)	Blending, Spinning
processes that make yarn into fabric	Weaving, Knitting
processes that expose yarn or fabric to water + chemicals (*) (most 'wet' processes)	Dyeing, Sizing, Desizing, Scouring, Bleaching, Mercerising, Finishing
Processes that expose fabric to print-paste or inks (no watery solution used on the fibers)	Printing
Processes that heat (and dry) fabric	Drying, Singeing, Curing
Processes that cut and sew fabric	Cut, Make and Trim
(*) 'chemicals' are: pigments & dyes, soaps & detergents, acids, alkali's and other chemicals.	

2.3 The Extended Textile Industry Product Chain

The textiles industry in South Africa is an example and has an important function as a consumer of materials and services, and many upstream and downstream industries rely on the textile industry directly or indirectly. Figure 2-1 gives an overview of all related industries in the extended textile product chain, 'upstream' from the textile industry.

According to the Textile Federation estimates, in excess of 360 000 jobs are dependent on the South African textile industry. This includes the over 71,000 directly employed by the industry, and further accounts for those employed in related industries (including approximately 80.000 workers employed on the cotton farms). In this case, 'related' refers to those industries that have a direct association with the textile industry, including the following:

Table 2-3: Overview of industries 'related' to the textile industry

- ***Agricultural** Sector* (mainly cotton farming)
- *The **Chemical Processing** Industries* (manufacture of synthetic fibres and textile processing chemicals
- *Downstream* ***Manufacturing*** and the ***Retail*** *trade* which uses and markets the various textile products
- ***Transport** and **Packaging** Industries*

From a 'consumption' perspective, the industry consumed over R 6.2 billion during the period under review (1996) of the last census of manufacturing (Statistics South Africa, 2000). Intermediate Consumption is defined by Statistics South Africa as including purchases of materials, admin fees, payments to other establishments for work done, rent and other charges.

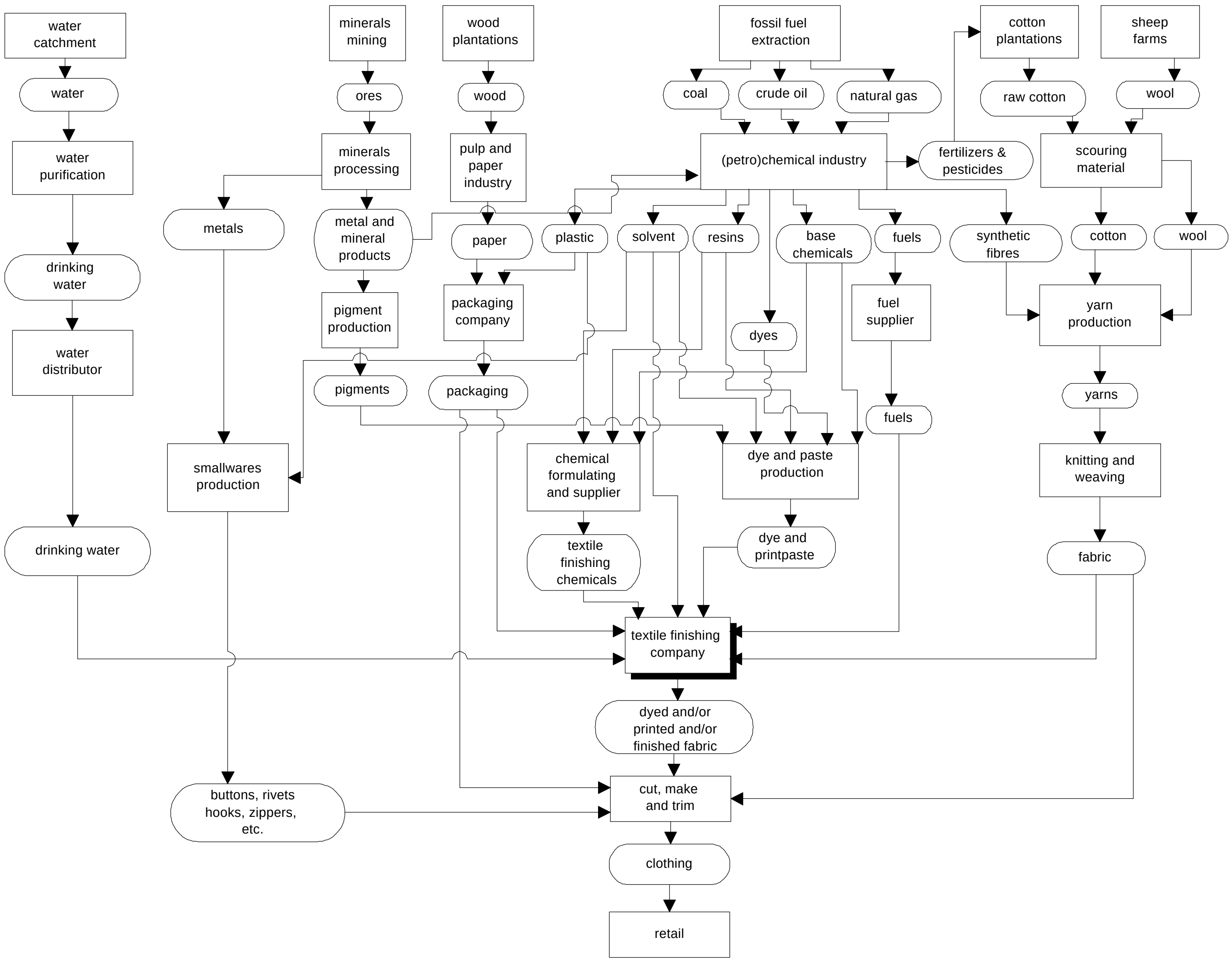

Figure 2-1 : Material flows to a textile finishing company

2.4 Environmental Impacts of Textile Manufacturing in South Africa

Most textile companies in South Africa where built during a period when there was little concern for the impact they would have on the surrounding environment, thus they are now poorly equipped to deal with the size and content of the modern effluent streams. In typical textile operations, both chemical and mechanical treatments are used on raw materials to produce a final product. It is the disposal of the removed raw material components that lead to the problems that have raised the Textile Industry to one of the four most polluting industries in the country (EMG, 1993). Textile processing generates many waste streams, including water-based effluent as well as air emissions, solid wastes, and hazardous wastes. Table 2-4 identifies the majority of waste streams generated by the Textile Industry. Environmental problems in the industry are typically associated with untreated liquid effluent, but also include solid and hazardous wastes, noise, energy and emissions to air.

Table 2-4:Textile Industry Waste Streams

Waste Type	Waste Source
Air Emissions	
Mists Particulates Fumes Volatile Organic Compounds (dye carriers, solvent scourers) Mineral oils and other vapours Knitting oils Fiber finishers Softeners Urea (from continuous printing and thermofix dyeing of fiber reactive dyes)	Atmospheric dye baths **Point Sources** (specific discharge points such as stacks or vents, that are intended to be the point of atmospheric release for emissions) **Boilers** (main point source in textile industry), **Ovens** (high temperature drying and curing ovens), **Storage tanks** (Bulk storage tanks usually have open vents to allow equalization of pressures) **Fugitive sources** (more general atmospheric emissions, e.g. evaporation, leaks, spills) **Solvent-based cleaning activities** (general facility clean ups and maintenance, implement and parts cleaning, print screen cleaning) **Wastewater treatment systems** (aeration of secondary activated sludge, biological treatment ponds) **Warehouses** (fabric stores can emit volatile emissions from process residues or finishing chemicals that remain in the fabric) **Spills** (can emit volatile pollutants for years unless immediately cleaned up using correct protocols.
Liquid Wastes	
Colour residues in dying wastewater **Electrolytes** in dying wastewater **Metals** and phenols in dying wastewater (low concentrations) **Aquatic toxicity** in dying wastewater Wastewater containing **metals, dyes, chemicals** **{NOTE: this is the largest waste stream in the industry}**	Atmospheric dye baths Wastewater treatment plants on site Wastewater bulk storage facilities Mostly high BOD, highs solids and neutral to alkaline pH
Solid Wastes	
Fabric off cuts and waste (accounts for 35 – 60 % of all solid waste) Paper/trash Wastewater sludge Cardboard, packing material (wrapping film, baling wire, wooden crates, paper sacks, paper; metal or plastic drums; etc.) Fly/bottom ash (from boilers) Chemical containers (such as bags and drums) Plastic cones and tubes (used to transport cotton yarn etc.) Oils, solvents **{NOTE: This is the second largest waste stream by volume in the industry}**	Wastewater treatment plants Cut, make and trim shops Public land fills Private land fills Boilers Packaging (both pre- and post-)

[adapted from EPA (1996a), EMG (1993) and UNEP (1994)]

The majority of the textile companies in South Africa (90%) discharge to sewer, with less than 10% discharging effluent into the sea, rivers, irrigation systems and landfills (Gilfillan, 1997). Due to these types of discharges, the individual companies must comply with limits set by the local authorities, who in turn, must comply with the requirements set by the DWAF. Due to the complex nature of textile effluents, refer Table 2-5, conventional sewerage treatment processes often do not sufficiently treat the effluents with the result that colour and other substances pass through the treatment works and enter the receiving water bodies (DANCED, 1999a). In one of the case-study companies it has even been found that effluents are not treated due to the unique dumping arrangement whereby the company shares a sewer with several other companies and the authorities have no method of tracking which company is responsible for the effluent being dumped.

The South African textile industry utilises large quantities of water and a wide variety of chemicals and dyes. This generally occurs during the wet finishing processes used to treat woven yarns and fabrics (EMG, 1993). International experience also shows that the wet finishing cycle is a major contributor to the metal pollutants (zinc, copper, chromium, etc) that are commonly found in dyes (UNEP, 1994). The main environmental impacts of the textile industry can thus be identified as follows: Large and inefficient water consumption, along with waste generation as highly contaminated aqueous effluent and sludge wastes.

Table 2-5: Characteristics of effluents of the South African textile industry (from PRG, 1999)

Process	Composition	Nature
Sizing	Starch, waxes, carboxymethyl cellulose, polyvinyl alcohol	High in BOD and COD
Desizing	Starch, glucose, carboxymethyl cellulose, polyvinyl alcohol, fats and waxes	High BOD, COD, suspended solids, dissolved solids
Scouring	Caustic soda, waxes, grease, soda ash, sodium silicate, fibres, surfactants, sodium phosphate	Dark coloured, high pH. High BOD, dissolved solids
Bleaching	Hypochlorite, chlorine, caustic soda, hydrogen peroxide, acids, surfactants, sodium silicate, sodium phosphate	Alkaline, suspended solids
Mercerising	Caustic soda	High pH, low BOD, high dissolved solids
Dyeing	Various dyes, mordants, reducing agents, acetic acid, soap	Strongly coloured, high BOD, dissolved solids, low suspended solids, heavy metals
Printing	Pastes, starch, gums, oil, mordants, acids, soaps	Highly coloured, high BOD, oily appearance, suspended solids
Finishing	Inorganic salts, toxic compounds	Slightly alkaline, low BOD

Textile effluents are generally grey in colour, although specific colours can come from more specialised processes, e.g. blue from denim stonewashing. In general they have a high BOD and high total dissolved solids. They have a neutral to alkaline pH and a high temperature (UNEP, 1994 and EMG, 1993). Other factors that determine effluent quantity and quality include the unit operations used and the degree to which water and chemicals are preserved in a particular manufacturing plant. Wool effluents are characterised by high BOD, high solids concentration and high grease content. Cotton finishing effluents are not as strong as those produced by the wool industry, but may have high colour content due to dying operations. They also have a high BOD, contain no grease and have a relatively low solids content (UNEP, 1994). In addition to the major pollutants such as dyes and chemicals, trace constituents that are washed into the effluents such as oils, surfactants and other substances are also of increasing concern. These may present an increasing health risk if the effluent stream is to be used downstream for drinking water in heavily populated areas.

2.5 Economic Importance and Situation

2.5.1 Contribution to South Africa's GDP

In its contribution to South Africa's Gross Domestic product (GDP), the Manufacturing Sector currently plays (and has for a long time) an important role. According to official statistics, the manufacturing sector consists of almost 26.000 enterprises with a total output of R 334 billion (Statistics South Africa, 2000), with the textile industry ('officially') contributing with approximately 700 enterprises.

From an industry distribution point of view, most of the manufacturing sector enterprises are located in *Gauteng* (44% and contributing 40% of total manufacturing output), followed by *Kwazulu-Natal* (20% and 22% of output), the *Western Cape* (18% and 15% of output) and the *Eastern Cape* (6% and 9% of output).

The manufacturing sector's relatively constant contribution to GDP - significant at about 25 % - needs to be seen as an important driving force in the overall economic growth of South Africa. It is not only the size of the manufacturing sector's direct contribution to GDP that matters, - the indirect contribution would be significant too. This can be attributed to the fact that the manufacturing sector is not only a producer of outputs, but a consumer of inputs too. The demand for goods from the primary sector, such as mining and agriculture, contributes strongly to the value added (and thus contribution to GDP) of *these* sectors. A vibrant manufacturing sector is thus also one of the cornerstones of a strong primary sector.

As can be seen in Figure 2-2 the sector's relative importance has declined slightly since 1990. From 1990 onwards, overall GDP has been growing at a *greater* rate than the manufacturing sector.

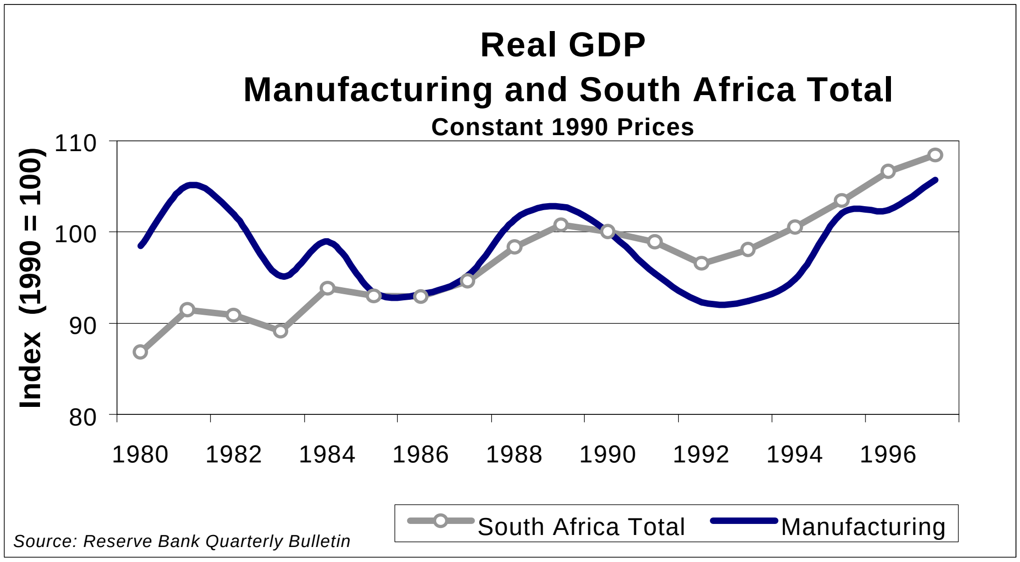

Figure 2-2: GDP of the manufacturing sector and South Africa overall

Textiles production and sales as a percentage of total *manufacturing* has been consistently fluctuating about the 2 % mark. It has declined slightly from a high in 1994 (2.1 %) to the latest available figures for 1997 (1.9 %) (see Figure 2-3). The textile sector's contribution to South Africa's GDP is approximately 0.7% (DTI & IDC, 1998).

While figures of approximately 2 % may at first appear insignificant, this needs to be contrasted with the size of the total manufacturing sector of the entire country. This lends importance to the textile sector's vital contribution not only to total manufacturing output, but also as a direct and indirect provider of employment, demander of goods and services as well as input materials, and contributor to South Africa's Balance of Payments (BOP).

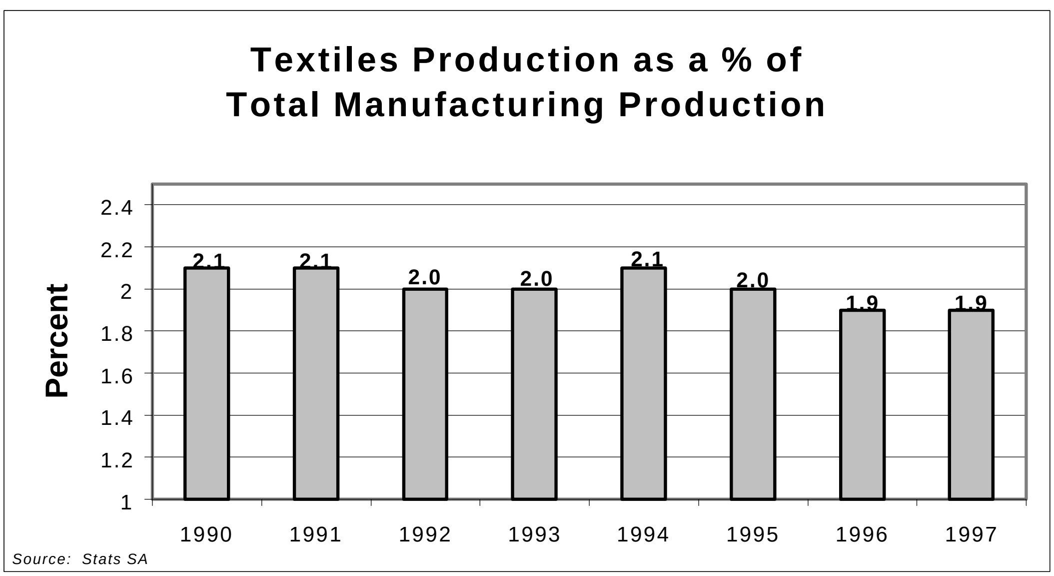

Figure 2-3: Textiles Production as a Percentage of Total Manufacturing Sector Production (adapted from Statistics South Africa, 2000)

2.5.2 Textile Industry Output

The South African textile industry has, according to the results of the latest census of manufacturing, achieved a gross output of R 9.2 Billion[1] for 1996 (Statistics South Africa, 2000). Of this, the '*spinning, weaving and finishing of textiles*' enterprises have contributed approximately 60%, with the '*other textiles*' contributing the remaining 40%.

Notwithstanding the pressure on output posed by imports, other factors have in the past few years negatively affected output growth. These factors include high interest rates, downscaling of export subsidies, difficulties with export market penetration, low retail sector growth, unsatisfactory labour relations, slack customs controls, lack of training and high cost of imported technology. While most of these problems have, to a large extent, been reduced, imports (both legal and illegal) continue to pose a major problem to the textile industry. Both China and Indonesia, 2 countries with significant textile production capacity and relatively weak currencies, continue to be able to export to other countries (including to South Africa) at prices lower than equivalent local production. Inconsistencies in the SADC member countries external trade regimes further undermine the sector, as they allow the continued proliferation of (often) illegal imports into South Africa. It is said, on the other hand, that the local textile industry could double its size (in terms of output) if the European Union and USA would open their markets to South Africa, without the present (very high) restrictions (DTI, 1998b).

The net profitability of the textile industry, using official statistics as the basis for calculation, is approximately 4.8 %, which compares unfavourably with the average manufacturing sector profitability of 7.8 %[2].

Relative to most other industry sectors, the concentration ratios are low, and point to a flat industry structure that is, on the whole, not dominated by a few very large enterprises.

Most enterprises falling into the '*spinning, weaving and finishing*' categories have relatively large output (i.e. in excess of R4 million), while '*other textiles*' fall mostly into the R 400.000 – R 2 million category.

2.5.3 Employment and Real Earnings per Employee

As can be seen from Figure 2-4, employment in the textile industry has decreased significantly in recent years. This is mainly due to attempts to increase productivity by restructuring. Although skills requirements are relatively low, a lack of training has contributed to labour generally being regarded as unproductive and not contributing to international competitiveness.

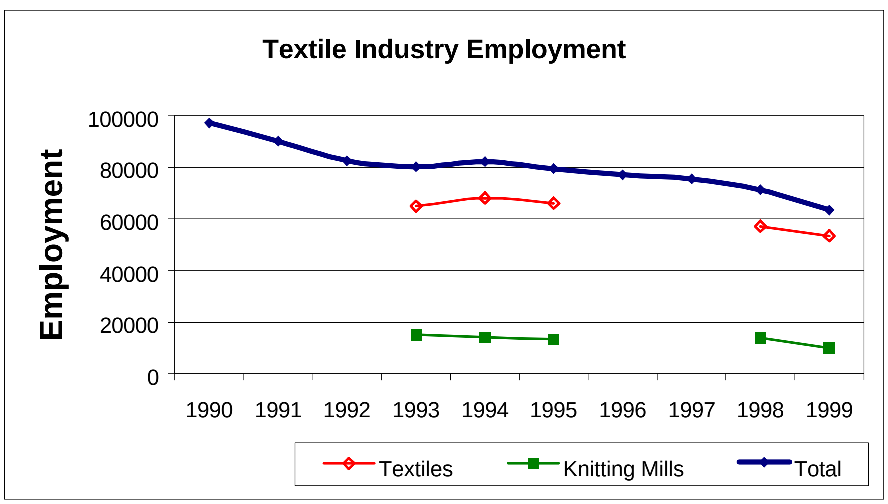

Figure 2-4: Textile industry employment

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[1] Note that the above figures are from the latest available *overall* census of manufacturing. Separate Value of Sales figures released for the textile industry (i.e. major group classification only, no sub-categories) for a later period show a slight increase for 1998 to R 9.76 billion (up from R 9.2 billion in 1996).

[2] Note: These figures were derived by using net profit as a percentage of output (by value)

Employment in the industry is fairly un-concentrated, meaning that the largest 4 enterprises provide 26% of employment, and the largest 10 enterprises employ approximately 42% of the total workforce. In the *Spinning, Weaving and Finishing* sector, most enterprises employ between 10 and 200 employees, making most of them *medium-sized* enterprises. Enterprises falling into the O*ther Textiles* group for statistical purposes (i.e. automotive textiles, blankets, carpets, cordage, stuffed articles etc) are mostly *small-sized* enterprises in terms of employment numbers (i.e. <50 employees).

The South African textile industry is shown to be a medium – low wage employer, paying significantly lower wages than the manufacturing sector on average (see Figure 2-5). This might be explained by the fact that the textile industry's skills requirements are relatively low.

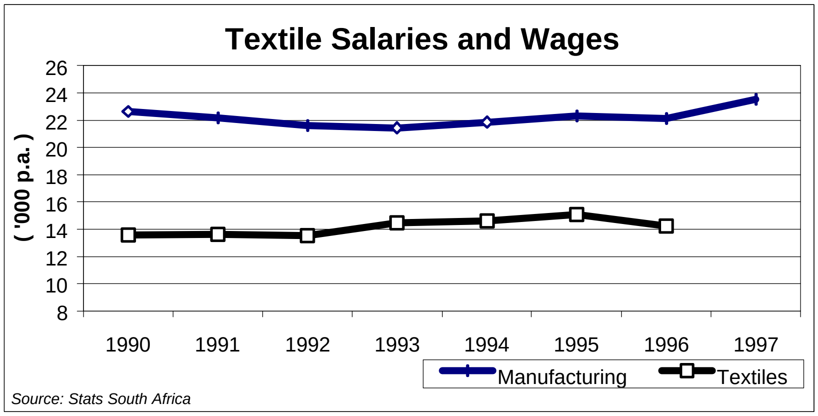

Figure 2-5: Textile industry salaries and wages

While real labour earnings only rose slightly in the past decade, labour productivity (i.e. output per wage unit) rose between 1993 – 1995, but has declined significantly since then (see Figure 2-6). This has had a very adverse effect on unit - labour costs, which have thereby increased by more than 62 % between 1990 and the end of 1996 (Statistics South Africa, 2000)[3]. This has resulted in a loss of competitiveness, and will have adversely affected South Africa's export volume (where losses in productivity were not simultaneously offset by a declining exchange rate). At the moment, most unions already seem to realise that strike action is exacerbating the textile industry's inherent difficulties and increases the risk of further decline in employment levels. These figures should send a signal to all role players in the textile industry by showing that the sector can ill afford to lose any further labour productivity by continuing to absorb increasing unit labour costs.

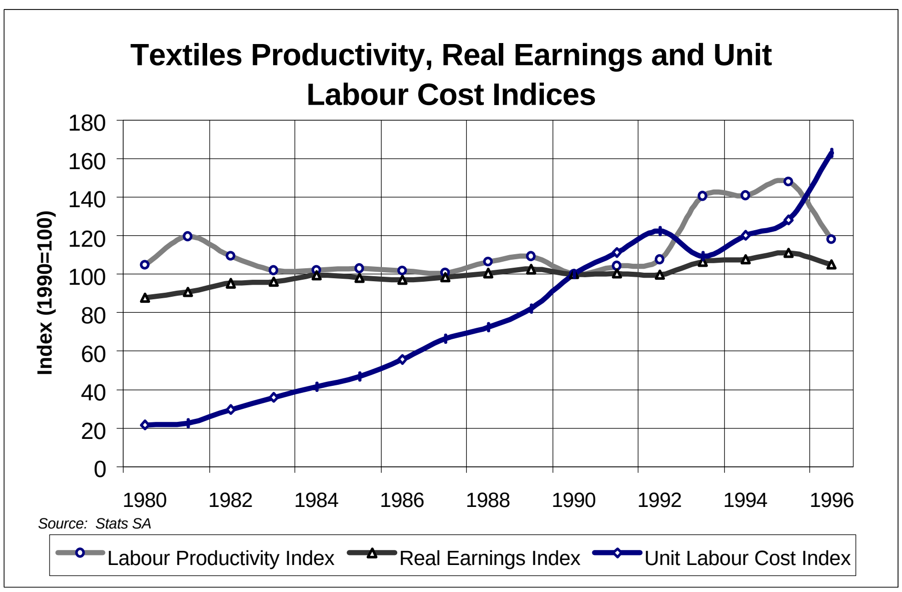

Figure 2-6: Textile industry productivity, real earnings and unit labour costs

[3] (Index 1990=100; 1996 = 162.9

2.5.4 Imports and Exports

Textile goods can be considered basic necessities, meaning that most countries have a textile manufacturing sector of some sort or other. This means that trade opportunities are generally very extensive, and offer significant scope for comparative advantage to be exploited by the countries involved. The table below shows the South African textile industry's main trading partners in the import / export of fibres, yarns, fabric and made-up textile articles:

Table 2-6: Origin and destination of South African Textile Industry Imports and Exports

Description	IMPORTS	EXPORTS
Fibre	United Kingdom; Zambia; Japan; Germany	Italy; France; United Kingdom; Germany; Taiwan
Yarn	Taiwan; Netherlands; Germany; Korea; Italy	USA; United Kingdom; France; Brazil
Fabric	Korea; Taiwan; China; Indonesia; Hong Kong; India	United Kingdom; Australia; Zimbabwe; USA
Finished Textile Articles	Malawi; Pakistan; China	United Kingdom; Zambia; Mozambique

To determine the importance of international trade to individual companies, we analysed the international material flows to and from the participating companies. The results (Table 2-7) show that even though there is a wide variation in the type of textile companies participating in this project, the textile companies are highly dependent on imports of raw materials, and show strong variation in dependency on exports of products.

Table 2-7: Imports and exports of the participating textile companies

Company Code	Estimated relative value of (in)direct raw material imports([1])	Estimated relative value of output that is (in)directly exported ([1])
T1	Very high	Medium
T2	-	-
T3	Very high	None
T4	High	Very high
T5	High	Low
([1]): local raw materials, but 90% at US$ world price.		

Both exports and imports have been growing in the past decade, although exports have grown at a greater rate. Import percentage increases however are off a much lower base level than exports. In absolute terms, therefore, the trade deficit for textiles has increased significantly since 1993, and has shown a 48 % increase in the 1993 – 1997 period (see Figure 2-7). In 1997 alone, imports exceeded exports by approximately R 1.6 Billion, which is up 14 % from the previous year.

The increasingly negative trade balance is likely to continue unless significant increases are achieved in output and overall manufacturing productivity. South Africa, being a signatory to the General Agreement of Trade and Tariffs (GATT), has agreed to continuously lower import duties and abolish quantitative restrictions, thereby opening up the domestic market to increased foreign competition. In 1995, South Africa agreed to phase out (or significantly lower) its tariffs on textiles over a 7 year period (starting in 1995), as opposed to a 12 year period as was required. The lower protection afforded to the local textile industry means that it has lost some of its competitiveness, which it can only recoup through efficiency improvements and a refocus of its production strategy.

In the long run the current trend of dismantling of tariffs and loss of competitiveness is unfavourable. A concerted effort to increase exports both as a percentage of total manufacturing production, as well as in absolute terms, is required. This holds advantages not only for the country's balance of payments and exchange rate earnings, but pressurises the textile industry into a more efficient allocation of resources. This is due to the fact that an industry that uses its resources efficiently, and even specialises in certain niche areas, is more likely to enjoy the benefits brought about by increased export market penetration. Successful export market penetration will naturally have numerous positive spin-offs for the industry (and country) as a whole, including higher productive capacity and greater investment in leading-edge technologies (Joffe et. al., 1995).

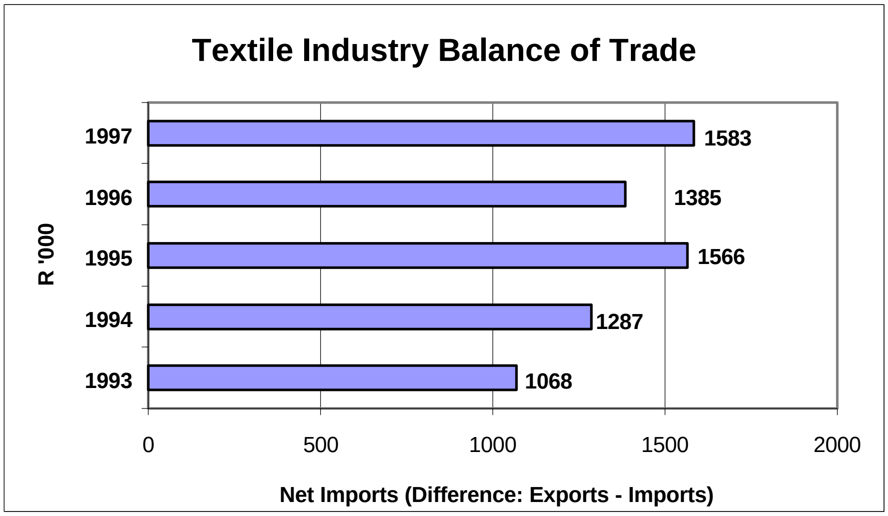

Figure 2-7: Textile industry balance of trade

However, the dismantling of trade barriers is not without conflict between the textile and clothing sectors, and gives rise to the so called 'Textile Dispute'. Textile companies are under increasing pressure by cheaper imports and loss of revenue from local consumers, and are thus cautious about an overly hasty tariff reduction. On the other hand, sections of the clothing sector welcome the potentially lower cost of textile imports and related gains due to more competitively priced input materials. (Gilfillan, 1997)

An issue that may make export penetration in developed countries (notably the EU and US) increasingly difficult is the growing introduction of (and demand for) e*co-labelling*. The eco-labelling of textiles has as some of its objectives the promotion of design, marketing and use of products which have a reduced environmental impact over their life-span. They are also seen as a source of information to consumers, as they provide assurances that the environmental impact of the product has been reduced without significantly compromising the use and durability of the product (Burdett, 1997). They thus allow consumers to determine which products adhere to a certain minimum environmental rating (in its production process), as stipulated in the regulations. These criteria are generally consistent between countries, and thus apply equally to imported or locally produced products (Barclay et. al, 1997).

Several regional Eco-Labelling schemes exist, including EU scheme, the Nordic Scheme, US Green Seal and Canada's Environmental Choice, as well as national labels including Nordic Swan (Norway, Sweden, Finland, Iceland), The Swedish Nature Conservation Society, Skal Organic (The Netherlands) and Stichting Milieukeur (The Netherlands) (Burdett, 1997). So-called "private" labels also exist (e.g. Ecotex and Ökotex), each covering a wider geographical area.

Mixed opinion exists as to the importance of eco-labelling in South Africa. While eco-labelling is likely to be an important strategy for the long term, local manufacturer are at present not constrained from exporting due to environmental demands. An example of this is a medium size textile manufacturer in Cape Town who went on an 8 week export reconnaissance mission to Europe and Australia. Never during all his meetings with potential textiles buyers were any environmental issues raised. However, the general expectation is still that international consumer demand for eco-labelled textiles, rather than pressure from environmental groups, is likely to influence the textile industry in the long term. While eco-labelling has been identified by both the DTI and *Texfed* as an important issue (House, 2000; Claasens, 2000), they doubt whether much success will be had in with eco-labelling in the short term. *Texfed* doubts eco-labelling will become an issue in the local market, as consumers are largely unconcerned about the environmental impacts of textile production, or at least are unwilling to pay a price-premium for such appropriately 'labelled' goods.

Very few textile manufacturers are at present willing to commit themselves to changing their production set-up in order to conform with eco-label specifications. Such an exercise can be both time consuming and costly. A survey for one of the participating companies (T1) in the project showed that a detailed investigation with a number of likely changes in the production process would be needed to comply with the EU eco-labelling scheme (Beers, 2000). The local market, at least, is largely unwilling and unable to absorb any price increases related to eco-labels at present (Claasens, 2000; Donegan, 2000; House, 2000, McLaughlin, 1999; Prosser, 1999; Saxon, 1999). It is , however, widely acknowledged that there is a potential need to introduce eco-labelling in order to better penetrate the high-value-added segment of the export market, especially that of Europe.

2.5.5 Cost structures

The cost of inputs obviously has a strong and direct effect on the price of an industry's outputs, together with other overheads such as use of land & buildings. Inputs as used in this context refers to raw materials such as yarns and fibres used in the production of textiles, as well as other variable costs such as water and electricity.

In the *spinning and weaving* sub-sector, labour accounted for the highest individual cost factor (at 27% of total cost), with basic chemicals, resins and plastics accounting for 18%. The *other textiles* sub-sector, input materials such as resins and plastics are the main cost factor (accounting for 28%), while labour cost is relatively low at 17% of total cost.

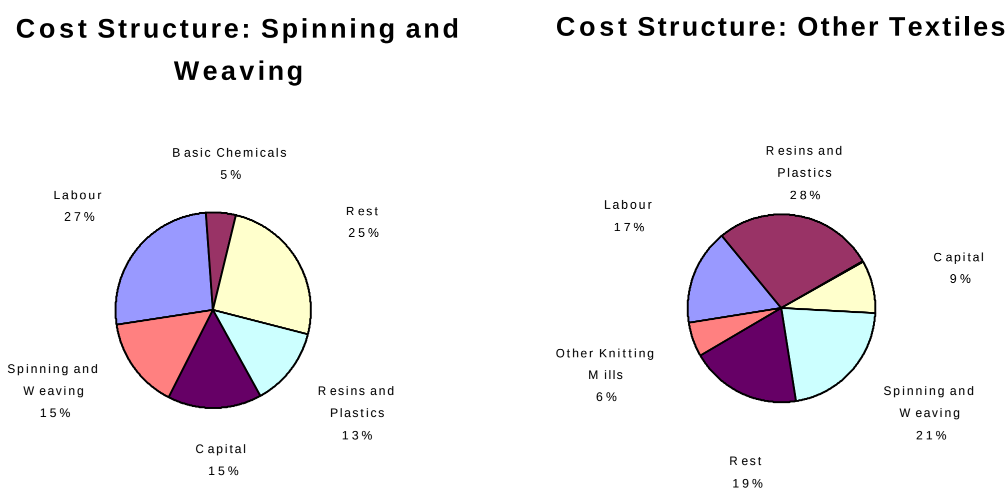

Figure 2-8: Cost structure of Spinning & Weaving, and Other Textiles (DTI & IDC, 1998)

2.5.6 Finance Costs and Investment

High finance costs have had a crippling effect on the South African textile industry, making only the most profitable investments financially feasible. Investments in the textile industry have fluctuated significantly since 1990. The cost of investment is measured mainly by the prevailing interest rates, and can be examined in Figure 2-9 below. A high or increasing interest rate will always have a negative effect on investments.

A positive trend of late is that interest rates have been declining steadily at the end of 1998 and 1999 (see Figure 2-9: Prime interest rate). It is expected that this trend will continue, and that by the middle of 2000, interest rates should be down to approximately 14 %.

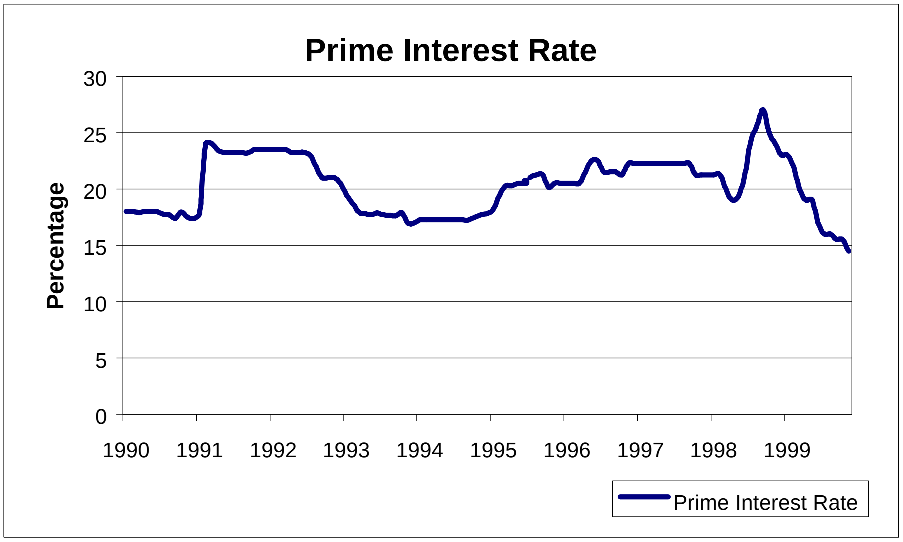

Figure 2-9: Prime interest rate

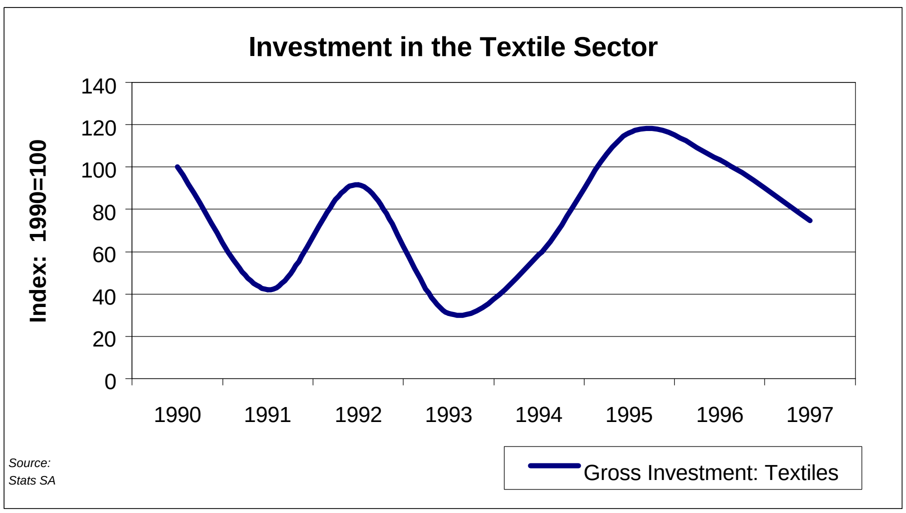

Figure 2-10: Textile industry investment levels

A very strong positive correlation exists between overall investment in textiles (as seen in Figure 2-10) and with investment trends in machinery and equipment. According to the latest *Census of Manufacturing* results (Statistics South Africa, 2000), capital expenditure on new assets was R 467 million, of which capital expenditure on *plant and machinery used in the production process* was R 422 million.

South Africa's recent investment pattern appears to be counter-cyclical to the international investment trend, and might be due to other reasons including investor confidence and political stability, the exchange rate, depreciation allowances granted by the South African Revenue Services, and the prevailing interest rates.

2.5.7 Utilisation of Production Capacity

Figure 2-11 shows that production capacity in the textiles sector is under-utilised.

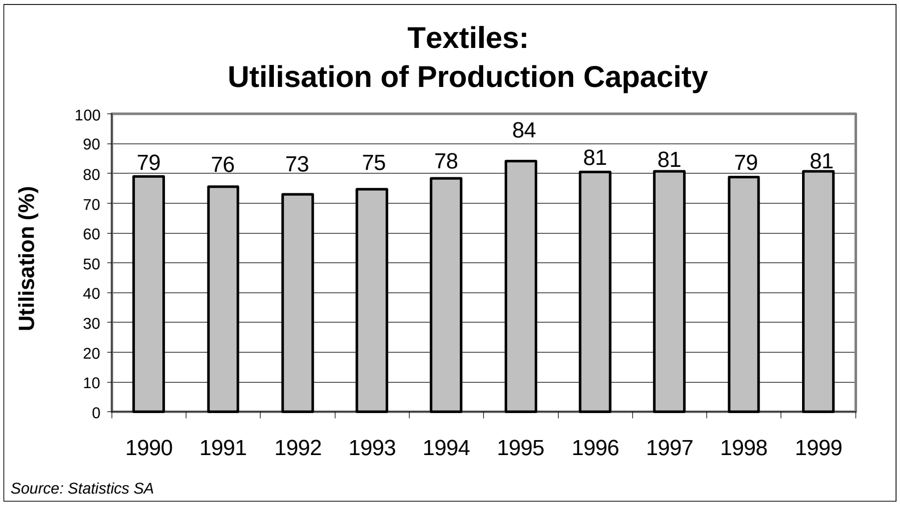

Figure 2-11: Textile industry utilisation of production capacity

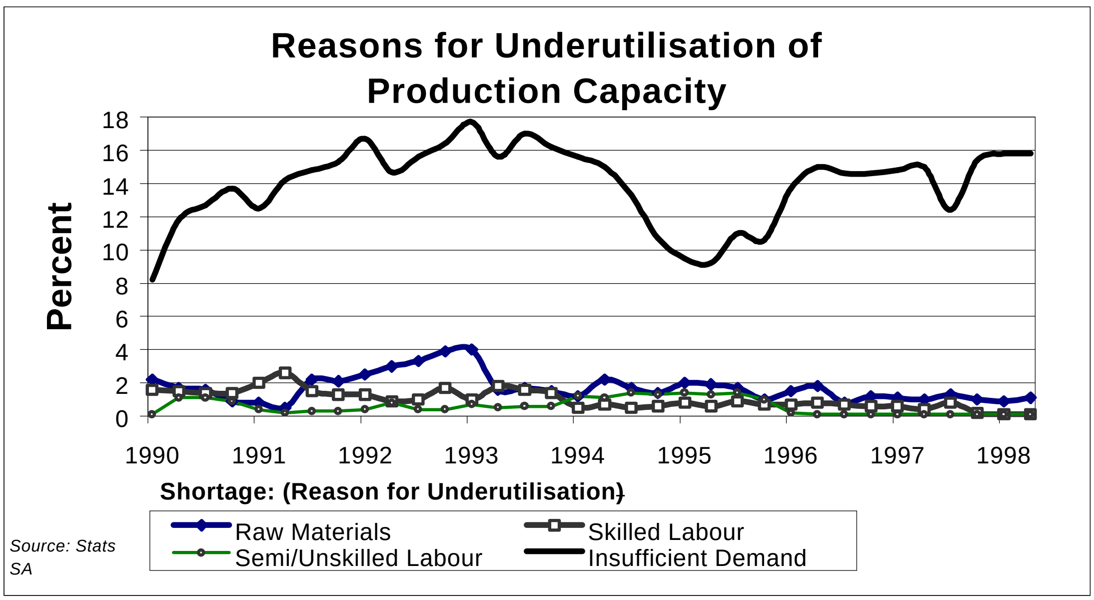

Figure 2-12: Reasons for under-utilisation of production capacity

As can bee seen from Figure 2-12, the main reason for the under-utilisation of production capacity has been a shortage of demand for its products (Statistics South Africa, 2000). Numerous factors can be responsible for this situation, including the significant amount of cheap imports (both textiles *and* clothing), the increasing amount of *illegal* imports flooding the market, labour problems as well as the general (difficult) trading conditions and sluggish economic growth in South Africa. A less significant (yet also important) reason for the under-utilisation of production capacity in the textile industry is a shortage of raw materials. Since 1996, the shortage of skilled workers as a reason for under-utilisation (of production capacity) has declined to an insignificant proportion.

2.5.8 Supply-Side Support Measures and Other Support

A variety of supply-side support measures are available mainly from DTI and IDC for industry amongst which the textile industry. A full list can be found in Naumann (2000b). Some of them are designed specifically for use by SMEs, as these firms constitute the majority of establishments in the textiles sector. According to the latest *Census of Manufacturing*, the textile industry received the following subsidies and incentives:

Table 2-8: Subsidies and incentives received by the textiles industry

Subsidies and Incentives Received by the South African Textile Industry	
Spinning, Weaving and Finishing	**Other Textiles**
R 48.5 million	R 34 million

In terms of non-financial support, a number of private sector associations (such as *Texfed*, *Clofed*) exist that collectively promote the interests of the textile industry, and represent the industry's viewpoints at negotiations with the government, employee organisations and foreign trade bodies.

Texfed is the most important of the textile industry organisations, due to its membership coverage (in excess of 50 companies, including the JSE listed ones) and wide-reaching agenda. *Texfed* acts both as secretariat for a number of similar associations and directly in matters of overlapping, common interest. Where required, *Texfed* also provides individual service to these associations, which include:

- South African Cotton Textile Manufacturers' Association (SACTMA)
- South African Worsted Manufacturers' Trade Association (SAWMTA).
- National Fabric Knitters' Trade Association (NFKTA)
- The Fibre Group, corporate members of Texfed that produce fibres.

Clotex is a joint textile and clothing industry committee functioning with the specific purpose of seeking ways to encourage co-operation between players in the (textile and clothing) pipeline, improving response times and improving efficiencies.

The *South African Dyers and Finishers Association (SADFA)* focuses on the wet textile processing industries. SADFA has branches in Cape Town, Port Elizabeth, East London and Johannesburg, but is traditionally the strongest in Kwazulu-Natal.

Other organisations that play a role in the sector include the *Centre for Science and Industrial Research* (CSIR) with its Textile Technology Division (Textek, responsible for research); the *South African Bureau of Standards* (SABS), which is responsible for testing and setting some of the industry standards (quality and environmental); the *National Productivity Institute* (NPI), which is responsible for finding and implementing productivity-enhancing improvement options; and the. *Textile Industry Training Board* (TITB), which provides and oversees training and formal education.

2.6 Utilisation of Raw Materials

The main raw materials in the textiles industry are fibre, water and chemicals. In this section we analyse the efficiency of the consumption of water and fibre, as well as electricity use. It is difficult to get reliable data on chemical consumption due to great secrecy on the part of both textile companies and chemical suppliers, and a concerted effort to obtain such data was not made.

2.6.1 Fibre use and losses

Cotton, synthetic fibres (e.g. polyester, nylon and acrylic) and wool are three of the most important fibres utilised by the South African textile industry, and some of the local demand for these materials is grown and/or produced locally. The South African textile industry is an overall net importer of fabrics and finished textiles, while being an overall net exporter of fibres and yarns (especially wool, of which over 90% is exported, and synthetic yarn). Some notes are appended at the end of this section on the local production of cotton and synthetic fibres.

During the project it appeared that a large amount of fibre (up to 50%) gets lost in different ways between the production of the fibres and the sales of the textile product to the user. These losses of fibre in the textile product chain were investigated in more detail during the course of this project (Harnstrom, 2000). The research focussed on textile fibre losses within the textile industry in the Western Cape during and between the operations from weaving and knitting to final garment including transport. The project did not focus on any specific garments due to difficulties to get response and figures from the industry. The different operations investigated have been looked at separately and were weaving and knitting, finishing and dyeing, printing and cut-make-and-trim (CMT) operations. The focus has been on companies that specialise in one specific operation. The mills, in general, are fairly large companies and not classified as SMEs. During the communication with the industry the main question was how much textile fibre of the textile and garment manufacturing becomes waste and reject.

Data was collected from 24 companies on textile fibre loss during and between weaving/knitting to final garment, transport included. The result is summarised in Table 2-9.

Table 2-9 Fibre losses in different parts of the textile product chain

	Company	Weaving	Knitting	Finishing	Dyeing	Printing	CMT	Transport	Reject	Total
1	Mills	2		x	x					7
2	"		<3	x	x					8[1]
3	"	1[2]		x	3[3]			0	4	7
4	"		0.3[4]	0.2	0.5[5]		18[6]	0.1[7]	2.5	24
5	"	3.3	3.5[8]	0.3[9]	0.3[9]	0.3[9]				
6	Print houses					<0.1		0	2-3[10]	<0.1
7	"					1,5			5-7[10]	1.5
8	"					0[11]			2-3[10]	0
9	"					0.9			2-3[10]	0.9
10	"					0[11]			0.5-1[10]	0
11	Design houses & CMT's			x	1.3[12]	1.7[13]	22[14]	0		24[15]
12	"						20[16]			20
13	"						12			12
14	"						22[17]	low	low	22
15	CMT's						24[18]			24
16	"					x	23[19]			23
17	"						25[20]			25
18	"						19[21]			19
19	"						x		2[22]	
20	"						22[23]		2-3[24]	22
21	"						23[25]			23
22	Design house					10[26]				35[27]
23	Retailer						10[28]			
24	Designhouse + retailer						25[29]	0.1	2.5[30]	25
	Range (average)	**1-5 (3)**	**0.2-4.1 (2)**	**0.6-7 (1.5)**		**0-1.7** (1)	**12-25 (21)**	**0.1**	**0.5-4 (2.5)**	

Figures in % of total production; footnotes in annex *
x: Operations are carried out, no figures on specific operations

Information gathered from textile industry representatives tells that the majority of the finishing and dyeing operations on fabric mainly takes place within the textile mills. The textile fibre loss figures received from the majority of the approached companies are based on rough internal estimations. Most companies do not know how to register losses accurately nor do they have the personnel, skills and technological resources to do so. The losses during weaving and knitting vary much with type of fibre, pattern and also the on the loom. Losses vary from 1-5%, polyester less and carded cotton with more short fibres has a higher loss factor. It was difficult to get hold of figures on fibre loss during finishing and dyeing operations. Textile fibre loss during wet processing is more difficult to measure, as it gets washed away with the waste water. Losses during printing vary mainly with the client's request. If the client does not want any trimming done to the fabric, then the fibre loss in the print house is next to nothing. The reject allowance is generally 2-3%. No companies tend to have any problems with losses during the transport of textile goods. The very few figures on losses due to theft and damage during transport are low.

The companies that generate the most textile fibre waste are the cut make and trim companies. The utilisation of the fabric varies with style, size, details and fabric width etc. The average cutting utilisation aim for T-shirts and men's shirts/women's blouses is >80%. 2-3% is added to the not utilised fabric due to remnants, faulty and damaged fabric etc. This indicates on a loss factor for cut, make and trim operations near 25%.

The companies that had more exact figures (not estimations) on losses were generally the bigger companies dealing with their own material and export. These companies seem to be more efficient generally. Printing and cut make and trim industry are to a large extent commission based. Companies that operate on a commission basis have generally a reject allowance agreement with the client. The reject does rarely become waste.

The losses vary considerably between the different textile handling operations and can not be compared with one another. The total (average) loss during the textile operation chain included in this project adds up to about 30%, not including reject.

There was only very little information available in literature and reports on this specific field, and the number of interviewed companies was relatively low. Although this makes the evaluation of the result more complicated, the conclusion is justified that approximately a quarter and up to a third of the fibre does not end up as product on the shelves. The majority of the loss comes from the cut-make-and-trim (CMT) phase of the production chain. This means that the lost textiles has already been treated with water and chemicals, and environmental impacts have been caused during the production of these textiles. A reduction of the losses in the CMT phase could therefore also contribute to a considerable reduction of the environmental effects of the textile production chain. In order to evaluate this in the context of the local (South African) environment, the following brief notes on cotton and synthetic fibre production may be useful.

a) Cotton

There are conflicting statistics regarding the size of the local cotton industry, especially in terms of the percentage of local demand for cotton that is in fact being produced in South Africa. According to the *Textile Federation*, the local cotton industry is said to be afforded unwarranted protection, even though it only satisfies about 33% of local demand (Textile Federation, 1998). On the other hand, figures released by *Cotton South Africa* state that the local cotton industry supplies approximately 65% - 70% of the local cotton demand at present (Bruwer, 1999). This difference in the provided figures should maybe be seen in the light of the Textiles Dispute (mentioned above).

It appears as if the quality of locally produced cotton adequately meets the requirements of the South African textile industry (i.e. mainly of cotton spinners), although concern has been expressed about the variation in the specification of qualities by spinners (DTI, 1994).

b) Synthetic Fibres

The use of synthetic fibres appears to be on the increase, especially as new technology allows these fibres to be produced in an increasingly efficient and cost-effective way. South Africa produces and supplies a variety of synthetic fibres to the local textile industry. Not all of the locally produced synthetic materials are used in South Africa though, and the local industry both imports as well as exports part of its synthetic input material requirements. The quality and specification of some of the local materials, as well as the price-quality relationship, have been mentioned as being amongst the reasons for some textile manufacturers choosing to import. Rising international oil prices (oil being an important input component in the manufacture of e.g. polyester) are likely to place upward pressure on the price of some synthetic fibres.

There are approximately 12 producers of synthetic fibres in South Africa (e.g. *Hoechst, South African Nylon Spinners* etc.), who supply the local industry with nylon, polyester staple and filament, acrylic and polypropylene fibres. It appears as if there are no local producers of viscose fibre, although cellulose (as used in the production of viscose fibre) is produced locally (DTI, 1998b).

2.6.2 Water consumption

Water is mainly used in the textiles industry for the process baths, but in larger quantities for the rinsing and washing of the textiles between the different processes. Water consumption varies between companies and between processes. The average water intake of textile companies in South Africa is calculated at 159 kl/t fabric (Gilfillan, 1997).

Table 2-10 gives typical and target water consumption figures for different textile wet processes (PRG, 1999). Typical specific water use figures indicate the water consumption using conventional equipment with no waste minimisation in place. Target specific water consumption figures are based on experience and literature. The average effluent volume has been estimated at 80% of factory water consumption.

Table 2-10: Specific and target water use for different textiles processes

Process	Typical Specific Water Use (l/kg)	Target Specific Water Use (l/kg)
Continuous processes		
Sizing	2	1
De-sizing	4	3
Bleaching and wash	4	3
Scouring and wash	4	3
Oxidative desize-scour-bleach	4	3
Mercerising and wash	20	4
Continuous dyeing no preparation	18	12
Wash range	12	4
Batch processes		
[1]jet - prep. and dyeing - preparation only - dyeing only	 80 to 160 30 to 40 40 to 85	 50 to 100 30 11 to 25
[2]jig - prep. and dyeing - preparation only	 45 to 80 15 to 20	 25 to 50 15
[3]beam - prep. and dyeing	160 to 200	100
[4]yarn - prep and dyeing	56 to 112	35 to 70
Printing		
Pigment wash off	12	4
Other wash off	80	50
Blanket washing	16	0.5
Screen washing	17	1
Finishing		
Typical finish	0.4	0

The price of water has traditionally been very low in South Africa, and the price of industrial water supplies is, in some regions (e.g. Cape Town), being used as an "incentive" (or at the very least, care is taken not to act as a '*dis*incentive') for firms to relocate to (or stay in) the area. There are various reasons for the historically low water prices, not least of which being the strong emphasis in the past was on supply-management as opposed to demand-management, as well as an inequitable distribution of the available water resources. Environmental and social considerations were also often ignored, meaning that many of the externalities related to water provision were not incorporated into its price.

A new Water Act has come into action since 1998. This includes the application of the most under-used water demand management tool, namely water pricing, which is likely to see industrial water being charged at significantly higher rates than in the past, and much more stringent quantitative and environmental monitoring geared towards the industrial sector. The price of water can thus safely be assumed to rise significantly over the next years, not only to help finance existing (and future) water infrastructure where necessary, but also to act as a deterrent for inefficient and wasteful water use.

Water prices vary greatly throughout the country, and are generally lower the closer an area is to a natural water resource. The Gauteng area, for example, already has far higher water prices than the Western Cape.

It is obvious that the incentive to use water more efficiently would be greatest in the Gauteng / Johannesburg region, where water (input) prices are more than double that of the Durban and Cape Town regions.

Current and expected future water costs for the regions listed below can be seen in the following diagram, which shows the (approximate) total current and expected water costs per 1000 kl consumption. Whereas Johannesburg and Durban have a single municipality each, the Cape metropolitan region is still divided into 5 sub-structures, each having autonomy regarding water tariffs and demand management.

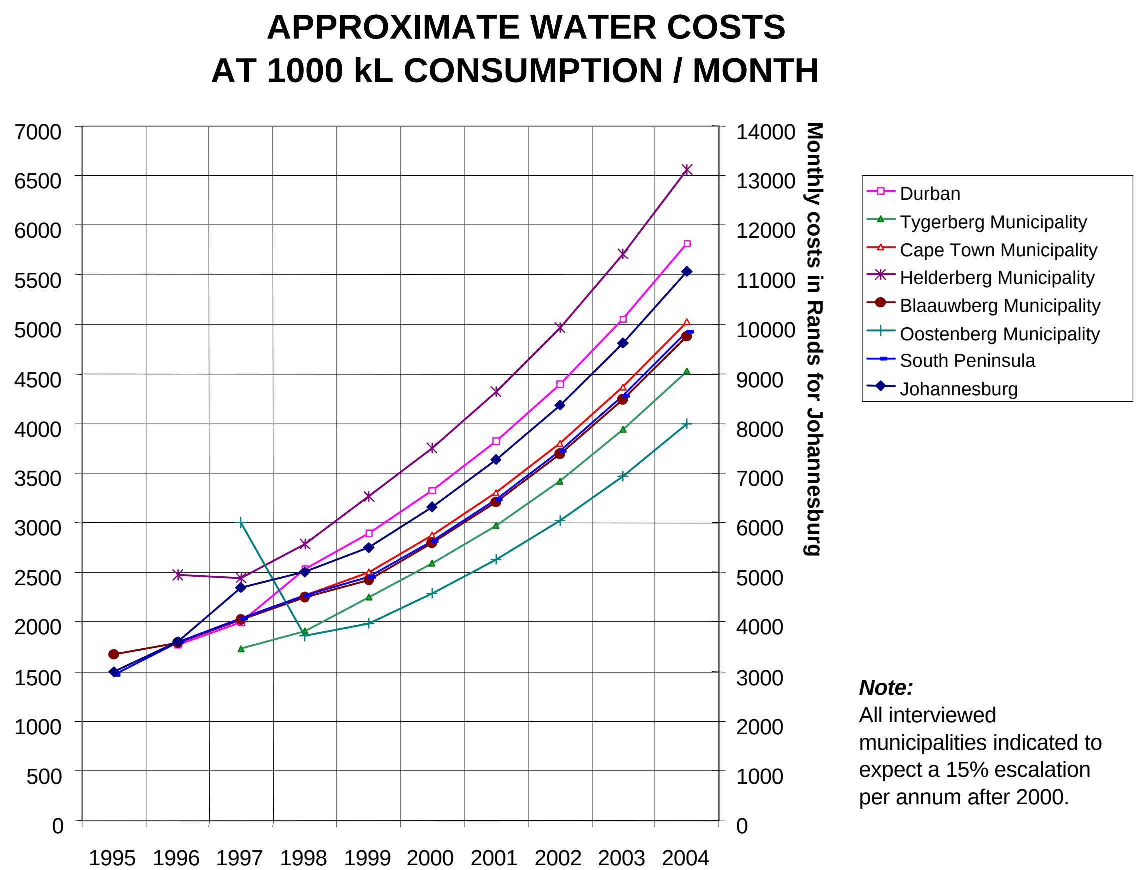

Figure 2-13: Past and future water charges in the Metropolitan areas of South Africa

The water costs incurred in the textiles industry were a relatively insignificant 0.3 % of turnover (Statistics South Africa, 2000). This is likely to change considering the national and local government's new emphasis on water pricing (and full cost recovery), as well as stricter compliance with environmental legislation.

2.6.3 Electricity

Electricity consumption is a further important input cost. According to the *Textile Federation*, the industry is the second largest consumer of electricity in towns and cities across South Africa in which it is situated (Textile Federation, 1998b). The textile industry consumed approximately R 155 million in Electricity in 1996 (Statistics South Africa, 2000).

Eskom, the national provider of electricity utility, has the policy that it seeks to provide energy cheaper than anywhere else in the world. Between 1987 and 2000 there was a reduction in the electricity price of almost 40% (in real terms). The price decreases (in real terms) that Eskom aims to achieve are on the back of internal efficiency gains through productivity improvements, reduced operating expenditure and cost containment (van Horen, 1997). Of the total electricity supplied to South African consumers, approximately 46 % is used by the manufacturing sector (NER, 1996). Eskom will shift in price burden away from high-voltage consumers, and towards subsidised residential and rural consumers (ESKOM, 1999), and this trend will consequently further benefit manufacturing concerns.

While the short to medium-turn outlook for relatively inexpensive electricity is good, one should take note of the fact that the vast majority of electricity (1994 = 89 %) is generated using coal-fired power stations (ESKOM, 1995). As this is now generally regarded as an environmentally unsustainable method of generating electricity due to the increasing scarceness , the inherent relatively large air pollution and the large waste quantities related to use of this natural resource, more environmentally friendly alternatives will need to be found in the long term. This is likely to affect the current trend of falling electricity prices in South Africa.

2.7 Challenges and Opportunities Facing the Industry

2.7.1 Trade liberalisation

There are a number of both challenges as well as opportunities facing the industry. The liberalisation of international trade is often seen as both a threat and a benefit. Trade liberalisation coupled with the Southern African Free Trade agreement *(SADC FTA*) will only be successful if tariffs and subsidies amongst the member states (i.e. Southern African Development Community) are brought in line and become consistent with one another.

According to 1998 customs statistics (Textile Federation, 1999), more *imports* flow into the country from SADC countries than is *exported* to them. Approximately 44 % of the import value from SADC countries represents agricultural fibres (mainly cotton), as many of these countries have well developed cotton industries. 39 % of the import value from SADC countries represents clothing, which is mainly attributable to the fact that these countries have very low wage rates. On the other hand, South Africa enjoys an advantage in the production of man-made fibres , filament yarns and industrial textiles. The value of woven fabrics, clothing and household textiles imported from Malawi has increased significantly since 1996.

2.7.2 Exchange rates

While it is entirely beyond the control of the industry, the fluctuating exchange rate poses significant dangers to the industry. This is for various reasons: a declining exchange rate increases the cost of imported machinery and equipment, as well as the price of imported input goods used in textile manufacturing. Likewise, higher exchange rates increase the incentive to import textiles illegally, and to exploit avenues such as Malawi and the SADC FTA to avoid some of the import duties. This seriously harms the local textile industry. A detailed discussion can be found in Naumann (2000b).

2.7.3 Raising of capital

Another threat facing the textile industry is the difficulty that is often experienced raising capital, for a number of reasons. Amongst the large, listed firms, this may be attributable to negative general sentiment towards the sector, and the fact that financial institutions are wary of lending to an industry that faces the problems of competitiveness and declining productivity as the textile industry does. On the other hand, a reason for the barriers encountered by smaller firms may be the fact that SMEs are often perceived to be a significant risk to institutional investors. Due to a widespread lack of understanding of SMEs, many financial institutions thus tend to rely on collateral rather than potential profitability of the business and its ability to repay any loan (DTI, 1998a). Difficulties experienced in raising loan finance (related especially to its cost and collateral requirements) are thus a significant impediment to SME expansion, and indirectly, a threat to the overall textile industry.

2.7.4 Productivity

The South African textile industry (and the manufacturing sector as a whole) is widely regarded as having low productivity. Competitiveness (of which *productivity* is a 'sub-set') essentially depends on a number of factors, and is driven most notably by technology (production and information technology), market conditions (availability and focus on niche markets, comparative advantage etc) and processes (quality and skills, productivity, strategies). To enhance the industry's competitiveness, any industrial strategy needs to focus on improving overall productivity. Some of the reason for the current situation (of low productivity) are the following:

Table 2-11: Reasons for Low Productivity and Competitiveness in South African Industry

• low investment in training and low skills development,
• inefficient capital-labour ratios,
• outdated technology, particularly in the textile industry (DTI, 1994)
• a focus on competing with the increasing volume of imports from the Far East (whose wage rates are far more 'competitive' than those in South Africa), rather than focusing on greater value-added production and niche markets
• deterioration in profitability in the textile industry (although this is both a cause *and* effect of low competitiveness)
• an inability of the textile industry to source all its input materials at world prices, as some protectionist measures still appear to be in place ,
• an at times confrontational atmosphere between employee (organisations) and employers,
• political and social instability, and consequently
• low business confidence in the textile industry.

2.7.5 Trade union activity

Strikes and mass action by unions have, no doubt, strongly contributed to the steep per-unit labour costs in recent years, and subsequent losses in international competitiveness. The overall attitude by trade unions does, however, appear to have shifted to greater co-operation and negotiated settlements, and some of the age-old (mis?)perceptions between the private sector and trade unions appear to be on the decrease.

2.7.6 Development of Small Businesses and Informal Sector

While a significant portion of the South African textile industry's sales output, exports, employment creation etc. are due to large (often publicly listed) companies, the rest is generally made up of SMEs and even the (largely unexplored) informal sector. While these SMEs play an increasingly important role (especially in terms of employment creation), the general trading environment and legislative framework is often not conducive to significant growth in this 'sector'. Research has often shown the importance of supporting SMEs, although these enterprises often see very little of this real 'support' that is offered to them. The government has realised this and has identified SMEs and the informal sector as an important feature of the clothing and textile pipeline (DTI, 1994). This realisation was important to a new strategy for the textile industry (House, 2000).

The main constraints facing SMEs and informal sector enterprises were identified as being (DTI, 1994):
Lack of access to finance; (esp. lack of access to affordable (start-up) finance and working capital, due to the perceived risk that SMEs pose, while successful applicants for financial assistance are usually required to pay excessively high interest rates).
Access to Inputs; mainly *accessibility to fabric inputs* (wholesalers, SME manufacturers), *accessibility to apparel outputs* (informal traders), and *the cost of inputs* (SME manufacturers, wholesalers, informal traders). It seemed like communication within and between the textiles industries, the clothing industry and the bigger textiles product chain (pipeline) needed to be improved. Textile manufacturers needed to "ensure that cost efficient small minimum…" (order quantities) "…are more readily available to SME manufacturers", that "manufacturers, fabric wholesalers and SMEs need to ensure they are regularly informed of the market requirements of each other", and "pipeline participants…" (referring o both textile and clothing manufacturers) "…need to ensure that downstream consumers have easy (locational) access to their production".

Training and Development; SME entrepreneurs (and their employees) generally have limited education and skills, which has a negative impact on the viability of the enterprise.
Markets; market opportunities, both domestic and especially internationally, have not been optimised, especially by SMEs.

It can be seen that the available factors of production (“land, labour, capital, entrepreneurship and technology”) are often not used in an efficient and productive ‘mix’. South Africa’s unique position of being a developing country yet with a developed world infrastructure has created a platform for further expansion and growth of the textile industry. Only with closer co-operation between all parties involved in the textiles pipeline, including financial institutions, government, trade union and the clothing sector, can the threats facing the industry be conquered.

3 The Metal Finishing Industry in South Africa

3.1 Broad Overview of the South African Metal Finishing Industry

The metal finishing industry consists of manufacturing sector enterprises involved in the coating of metallic (or plastic) objects with one or more layers of metal, paint, plastic or ceramics. This includes the electroplating, plating, polishing, anodising and colouring processes that coat or finish metal or other formed products (Metal Finishers, 1993). This chapter is largely based on work by Naumann (2000a), although significant inputs from Janisch (2000), who presents a comprehensive argument for waste minimisation opportunities in this industrial sector, are also acknowledged.

3.1.1 Classification: Job-Shops and Captive-Shops

As metal finishing processes (or more appropriately, surface finishing processes) are used along the production cycle of many manufacturers, the metal-finishing industry is classified as a separate industry only to a limited extent. This means that the statistical evidence usually refers to *job-shop* metal finishers, and can be taken only as a starting point for extrapolation to the metal-finishing industry as a whole (i.e. to include captive metal - finishers). Job-shop metal finishing operations are those that do not manufacture the components themselves, but offer the service of metal finishing to other manufacturers and the public. *Captive-shops*, on the other hand, perform metal finishing activities on the products that they manufacture themselves, or subsequently use in their production line. These enterprises are usually much larger than job-shops, and are especially prevalent within the automotive and automotive components industry.

For the purposes of this report, the metal-finishing industry refers to both job-shop as well as captive-shop metal-finishing operations, unless stated otherwise.

From an environmental point of view, the metal-finishing industry is a significant producer of hazardous waste as measured by waste quantity per Rand unit of output / contribution to GDP (EMG, 1993). The high toxicity of many of the metal-finishing industry's input material, and low degradability, necessitate the adoption of improvement options to 'clean up' the industry.

3.1.2 Distribution and Number of Enterprises

There are no proper data available on the total number of metal finishing companies in South Africa. Industry and chemical suppliers suggest about 500 job shop platers in South Africa. In a survey conducted during the project, we contacted over 300 metal finishing companies throughout South Africa excluding the automotive industry and the automotive component industry and found that about half of them were classified as job shops (Jänisch, 2000). That would mean that there could be as many as 1000 metal finishing companies in South Africa. Based on different sources (Statistics South Africa, 2000; Danks, 2000; Gafin, 2000; Hutton, 2000), the following estimation can be made of the distribution of Metal Finishing companies over South Africa:

Table 3-1: Distribution of metal finishing companies over South Africa

Region	Percentage of Metal Finishing companies
Johannesburg, PWV-triangle	50%
Durban, KwaZulu-Natal	25%
Cape Town, Western Cape	20%
Port Elisabeth and East London, Easter Cape	5%

The vast majority of job-shop (independent) metal-finishers operate in the main metropolitan regions. It appears as if an increasing number of captive shop metal-finishers in the metropolitan regions are unwilling to continue having metal-finishing processes done in-house (for various reasons, including not wanting assets and liabilities to appear in their financial statements having the perceived risks of metal-finishing), and are increasingly outsourcing the work to job-shop (contract) metal-finishing companies (Hattingh, 2000).

3.1.3 Application of Metal Finishing processes

Metal-finishing operations are used for many reasons, and provide protection for the base metal, or change the surface of the base material to provide a number of desirable characteristics. These include the following (WRC, 1987; Hanson, unknown)':

Table 3-2 : Applications of Metal Finishing Processes

• Abrasion Resistance	• Light Reflectivity
• Corrosion Resistance	• Enhanced Electrical Properties
• Enhanced Appearance	• Enhanced Temperature Resistance
• Enhanced Lubrication	• Enhanced Wear Resistance
• Enhanced Solderability	• Non-Toxicity

Metal-finishing operations are used predominately in the following manufacturing sectors:

Table 3-3: Industry Sectors using Metal-Finishing Processes

• Automotive and related components	• Electric Components
• Aerospace	• Furniture
• Commercial Aviation	• Household Appliances
• Communication	• Jewellery, Coins
• Computer / Electronics	• Motorcycles / Bicycles
• Defence	• Steel Mill Products
• Drilling Equipment	• Tools and Machinery

3.2 Processes Used in the Metal Finishing Industry

Processes used by the metal-finishing industry involve the cleaning, hardening or softening, smoothing or roughing and conversion of the object's surface using chemicals. In general, the metal surface treatment and plating operations used by metal-finishing operations can be divided up into 3 stages, namely surface preparation, surface treatment and post treatment.

Plating operations are typically batch processes, whereby an object is immersed in a bath containing various reagents to achieve a chemical reaction. This chemical reaction is the integral part of metal plating operations, and results in the object being coated to the desired surface finish and quality characteristics.

During the project we carried out a survey of metal-finishing enterprises in South Africa, which found that most companies were involved in electroplating (42%), followed by powder coating (28%), wet painting (22%), phosphating (18%) and hot-dip coating / galvanising (14%). The results of the survey would appear to be in line with the fact that the electroplating industry has the lowest entry barriers, which is mainly due to the fact that both the set-up costs and the necessary skills requirements are relatively low, and demand for electroplating services remains high.

In the electroplating companies, zinc, nickel, copper and hard-chrome electroplating appears to be the most common types at 25%, 21%, 16% and 12% respectively.

3.3 The Metal Finishing Supply Chain

The metal finishing industry uses raw materials that originate from the mining and minerals processing industry as well as from the petrochemical industry. Besides that, the industry, like most manufacturing industries, uses water, energy and packaging materials. A picture of the material flows to a metal finishing company is given in Figure 3-1.

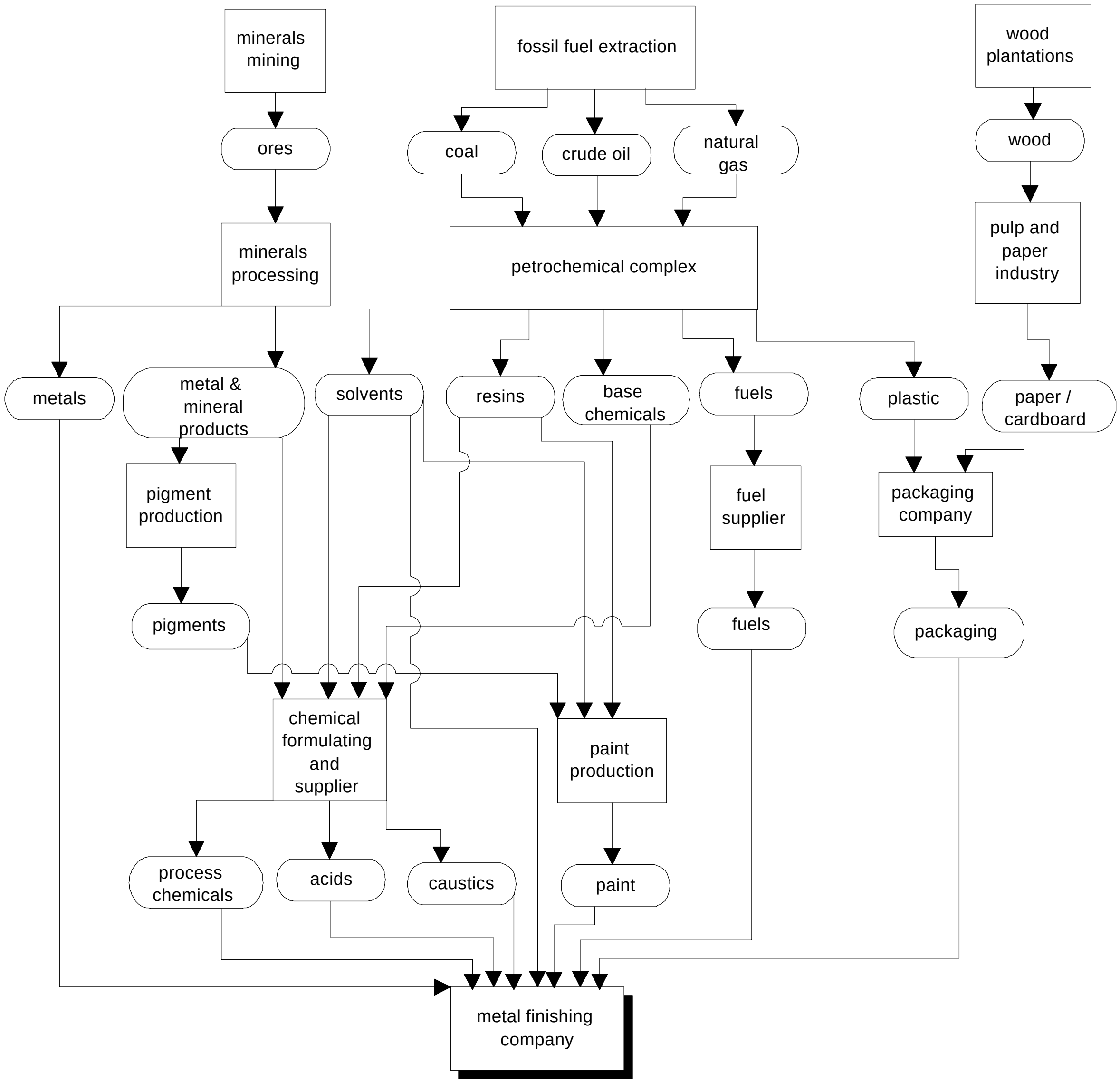

Figure 3-1: Material flows to a Metal finishing company

As for the textile companies participating in the project, we determined the degree to which the metal finishers trade internationally. Table 3-4 shows that the case study companies are relatively independent from the import of raw materials, as well as that most of the participating companies do not export their products.

Table 3-4: Imports and exports of the metal finishing companies

Company Name / Sector	Estimated relative value of (in)direct raw material imports(1)	Estimated relative value of output that is (in)directly exported (1)
M1	Low	Low
M2	Low (2)	None
M3	Low	Medium
M4	Medium	High
M5	Medium	None
(1): expressed as percentage of total raw material costs or product value that is im- or exported (2): local raw materials, but 90% at US$ world price.		

3.4 Environmental Impacts of the Metal Finishing Industry

Information regarding total wastes generated by the metal finishing industry was compiled by the Environmental Monitoring Group in 1993. The results indicates that although the contribution of the metal finishing sector to total waste in S.A. is not large as measured by waste quantity per Rand unit of output/contribution to GDP, more than 80% of the waste generated is *hazardous* (EMG, 1993).

The electroplating, anodising and chemical surface treatment processes have been found to be the most water-intensive amongst the metal finishing operations in South Africa, and water is not used efficiently in most operations (NATSURV2, 1987). The cost of water is cheap, providing no financial incentive to reduce water use in the industry. The same study found that approximately 80% of the annual water intake of the metal finishing industry is discharged as effluent. It was however found that larger electroplating shops operate more efficiently in terms of water use.

According to the NATSURV study, dumping of cleaning solutions and acids occurs regularly (ranging from every week for some to once a year for others) and this provides the bulk of the salt load leaving a plating shop. Sampling methods used to characterise the effluent from metal finishing operations are not able to take into account the periodic dumping of these solutions. The final report to the Water Research Commission on the national industrial water and waste-water survey (WRC, 1991), suggests dumping of process solutions provides the major source of pollution from the metal finishing industry and is particularly harmful to local sewage treatment works where such toxic influent can bring normal sewage purification to a standstill. Recommendations were that initial waste management efforts should be directed at these discharges.

While the larger metal finishing companies in South Africa generally follow acceptable disposal procedures, it is claimed that many of the smaller operations do not, with effluent containing heavy metal concentrations in excess of the sewer regulations commonly being discharged to drain (Barclay et al, 1999).

To control the amount of metals entering the sewage treatment system, municipalities impose Industrial Discharge Standards promulgated to limit discharges to sewer (WRC, 1998). However, these standards are often inappropriate or badly enforced and in some cases contribute to the problem. The practice of using concentration limits (for measuring reasons) rather than contaminant load encourages compliance by *dilution* both at factory and at municipal level (DANCED, 1999b). This practice does not reduce the total load and in fact often worsens the environmental impact due to increased water usage. In addition, the operation of industries and limitations on the ability of municipalities to practically monitor and control discharges continues to result in significant metal loads arriving at the sewage treatment plants in an unaccounted manner.

A study undertaken on a number of metal finishing enterprises in the Johannesburg area (WRC, 1998) has indicated that few actively practice effective on-site effluent management, and that the rudimentary pre-treatment (where it exists) is usually not well organised, operated or maintained in relation to compliance with existing by-law quality standards, or disposal of waste sludges generated in the process. The systems are largely left to run themselves, with ad-hoc desludging to sewer, or via waste contractors on an irregular basis. Although several plant operators cited waste haulers as the remover of its waste sludges it is apparent that the amount taken by waste haulers represents a *fraction* of the metal wastes generated by the group, with the majority of metal load being discharged to sewer. This has resulted in significant loads of heavy metals entering the sewerage system and ultimately accumulating in the sewage sludges of the treatment works and passing through into the receiving river environment (WRC, 1998).

The same study (WRC, 1998) found that in the Johannesburg area, the inability of certain municipal treatment plants to cope with the toxic loads from metal finishing operations has resulted in local authorities having to refuse such effluents from some companies. Municipal, and especially private-sector waste contractors, will generally only invest in treatment plants if they can be used efficiently, else they would allocate their scarce resources differently. Where certain treatment options are not financially feasible, this could be due to a relatively low supply of certain toxic effluents in a particular area, and thus little incentive for treatment facilities to invest in the relevant expertise and technology.

Naumann (2000a), has reported that discussions with Johannesburg Metro representatives revealed that the problem with metal finishing effluent for most sewage works is associated more particularly with the effect of heavy metal wastes on the composition of treatment sludges. The sludge from sewage treatment plants is traditionally sold off as 'Class D' sludge and used as a soil remediant (fertilizer) on farmlands, but this is often not possible due to this high heavy metal content, with the result that the sludge has to be disposed of to landfill.

The preferred solution is to prevent the discharge of the heavy metals to sewer as much as possible, although the use of penalties has not been successful in the past due to lack of enforcement personnel (Barclay et al, 1999).

Due to the limited waste sites available for the disposal of the toxic waste (such as those typically produced by the metal finishing industry), South Africa faces a waste management crisis. The approximately 1200 waste disposal sites around the country appear to be unable to deal with the high amounts of waste generated, especially hazardous wastes. Carnie (1996) quotes the Minister of Water Affairs and Forestry, Dr. Asmal, as saying; " …(South Africa) has a serious shortage of hazardous and toxic waste disposal and treatment facilities and an alarmingly high percentage (up to 50%) of such waste is being disposed of indiscriminately and illegally..". A further problem is that many waste sites are operating without the necessary license, and face closure when monitoring controls are strengthened.

A particular problem is evident in the province of Kwazulu-Natal, where at present, no disposal site for hazardous wastes exists in the province (only two low-hazardous waste sites), which is effectively encouraging illegal storage and/or dumping of hazardous wastes (Daily News, 1998). According to legislation, however, it is illegal not only to move hazardous waste across national borders, but also to transport it across provincial boundaries. While hazardous waste disposal facilities exist in the Western Cape, Eastern Cape and Gauteng, it is not only technically illegal of KZN firms to dispose of their wastes there, but also very expensive. Metal finishers therefore, have for some time, been faced with a situation where they are not able to dispose of their hazardous wastes legally. They are thus forced to engage in transportation of hazardous wastes to disposal sites in Gauteng, which is technically illegal, very expensive, and fraught with risks (Naumann, 2000a). A solution is presently being sought in Durban by glazing the heavy metal sludge into pebbles which can be used as raw material for the production of bricks (Hattingh 2000).

In many cases, outdated equipment and poor maintenance leads to increased water and energy consumption and the generation of unnecessary waste. Much of the problem lies with poor housekeeping often associated with low worker education and skill. Waste audits in twenty-five metal finishing companies (90% SMEs) in the Durban area revealed that the most common areas of wastage were excessive water consumption and loss of chemicals due to drag-out and spillage and that these problems were mainly a result of poor housekeeping practices (WRC, 1999).

It is speculated that the majority of metal finishers are unaware of the effect of their wastes or the real cost of their wastes. There is a general belief that waste management represents a cost to the company and not a saving. Since many metal finishers run their processes by attempting to attain production targets and dealing with crisis issues, environmental issues are often not even a consideration. It is suspected (based on phone conversations by a project team member with several industry members) that the use of solvents, cyanide, and chromium is still widespread within the industry, and that little attempt is being made to reduce their use mainly since metal finishers are unaware of the alternatives. At least three companies contacted for the survey however, indicated that they had stopped their cadmium plating line rather than deal with the complicated waste disposal requirements.

DANCED (1999b) claims that there is uncertainty in the metal finishing industry sector as a whole about the nature and scope of the environmental problems resulting from metal finishing production. There is little comparative data and benchmarking tools which means that companies are not aware of their relative performance in terms of Cleaner Production

Naturally, the intensities of the effluent streams of a particular metal-finishing firm relates directly to the level of technology, environmental awareness and production strategy followed. These variables are further dependent on the availability of capital and relevant technology, legislative and consumer pressure, competitiveness of labour and capital inputs, barriers to trade and commodity prices.

Wastes generated are not of a uniform type, but rather consist of air emissions, liquid wastes and solid wastes. A summary containing some of the main waste streams generated by the metal-finishing industry is provided in Table 3-5 (UNEP, 1998):

Table 3-5 : Waste streams from the Metal Finishing Industry

Metal-Finishing Industry Waste Streams	
Waste Type	Waste Source
<u>Air Emissions</u> Mists containing metals and acids Particulates Fumes Volatile organic compounds (VOC)	 All finishing activities Metal polishing, powder coating Acids / Alkalis Solvents, paint strippers
<u>Liquid Wastes</u> Wastewater containing metals, cyanide and used process chemicals Acids Alkalis Plating solutions containing heavy metals Ion exchange resin reagents	 Rinsing, cleaning of equipment, spillage Acid cleaning agents, pickling, etching Caustic cleaners Contaminated plating solutions that are no longer efficient Demineralisation of process water
<u>Solid Wastes</u> Precipitated metal sludges Filters and filter sludges Oily / greasy rags Metal polishing residues Paint residues Packaging and general wastes	 Wastewater treatment Filtering of cleaning and plating solutions Pre-cleaning Polishing of metals prior to plating processes Powder coating

3.5 Economic Importance

3.5.1 Output of the Metal Finishing Industry

Sales in the metal-finishing industry have declined significantly in real terms over the past 7 years, and net profitability is relatively low. Whereas the net-profit to turnover ratio of the overall manufacturing sector is approximately 8%, the metal-finishing industry has a ratio of only 2% (Statistics South Africa, 2000), making it relatively unprofitable.

Relative to most other industry sectors the concentration ratios in the metal finishing industry are low and point to a flat industry structure that is not dominated by a few very large enterprises.

As shown in Figure 3-2, the sales figures in metal finishing job shops have shown a significant decline since 1990 (1990 – 1998 -26 % drop, although the situation has stabilised since 1994); also, the brief upturn in 1997 does not appear to have been sustainable. As the data refers to the job-shop component of the metal-finishing industry alone, it is not a reliable indication of the overall turnover of all metal-finishing operations. The sales figures from the job shop also go against the trend in overall manufacturing performance, which after dropping between 1990 and 1993, has been growing significantly to reach pre-1990 levels during 1998. However the production volumes in the closely linked metal products industry have shown no significant changes between 1990-1997, so the growth in the manufacturing industry might be caused by another part of this industry sector.

Due to the strong interaction of a number of industries with the metal-finishing industry, the trend of the manufacturing sector may be a reliable rough indicator of output trends in the overall metal-finishing industry. An analysis of the overall manufacturing sector’s performance over the past 2 decades shows that output by this sector of the economy has been following cyclical trends (Naumann, 2000a). The manufacturing sector has roughly followed trends of the overall economy, expanding when the economy grew, and declining when national growth slowed down. It is likely that the overall metal-finishing industry’s output (i.e. both job- and captive-shops) will be strongly linked to trends in the manufacturing sector, which has been on an upward trend since reaching its lowest level (of the last 2 decades) in 1993.

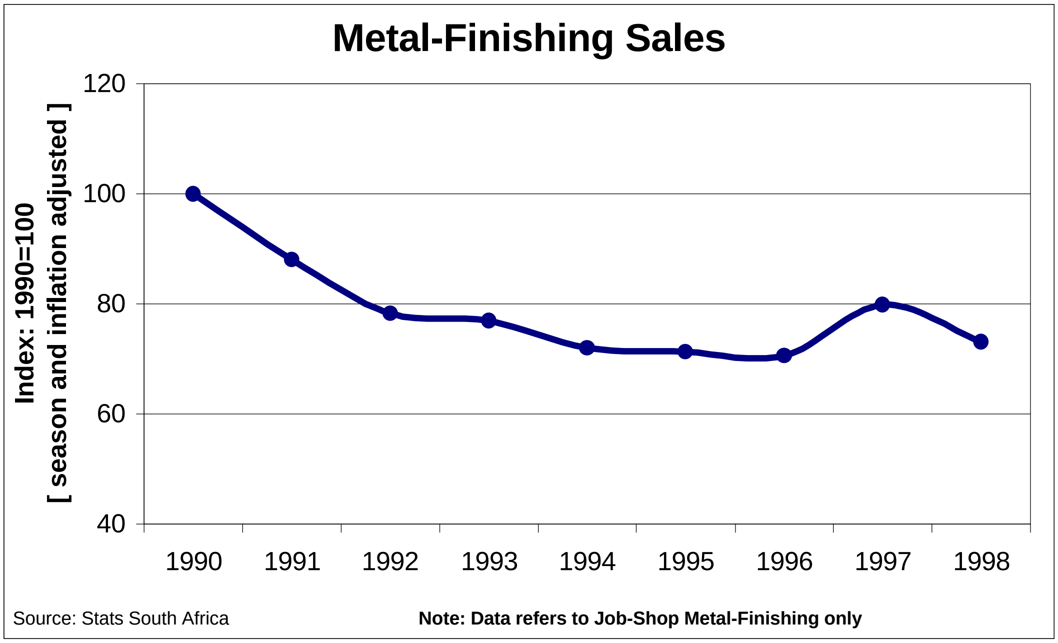

Figure 3-2 : Metal Finishing sales

3.5.2 Employment levels and labour costs

In South Africa only a limited amount of quantitative data exists for the metal-finishing industry, and some uncertainties prevail regarding the reliability of the official data as generated by *Statistics South Africa*. The available data of labour costs represents only the job-shop component of the metal-finishing industry (called *Treatment and Coating of Metals* by Statistics South Africa). The directly employed workforce ranges from 5,500 to 8,500 employees (see Figure 3-3), and according to the latest census results the relative contribution of the largest 4 firms in terms of employment is approximately 17%, while the largest 10 firms collectively contribute in the region of 28% to employment. From 1995 to 1999 this figure has declined slightly and is at present around 7,300 workers. The figure would appear to be consistent with the number of electroplating and galvanising firms being around 500 and 30 respectively (DANCED, 1999b).

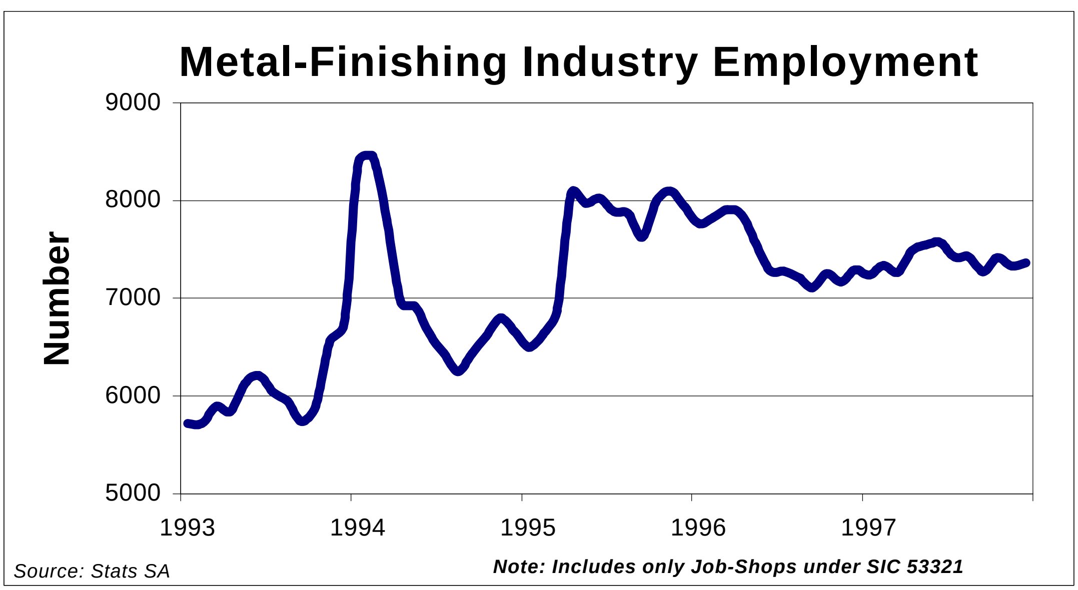

Figure 3-3: Employment in the Metal Finishing Industry (job shops only - SIC 53321)

The increased demand for labour at the end of 1993 drove up real wage rates to unprecedented highs (see Figure 3-4 below). The strong increases of between 1993 and 1994 were not sustained and employment numbers have been decreasing from 1995 onwards. This is similar to the employment trends in the metal products industry, an industry that is closely linked to the MFI, where employment has decreased by approximately 10% between 1990-1997.

The figure below also shows that labour organisations have been successful in achieving nominal wage increases equal to the changes in the rate of inflation. The metal-finishing industry is a medium-low wage employer, being well below the average manufacturing sector wage rate of R21,437 per annum (1993) to R 23,518 per annum (1997). This is likely to be attributable to the fact that this particular industry makes substantial use of medium to low-skilled workers, which naturally translates into relatively low wages and salaries.

This may also, however, point to a number of other possible causes, including:

- Low union membership due to difficulty penetrating an industry that consist of a large number of SMEs
- Weak trade unions
- Financial difficulties in the sector (poor profitability as discussed above)
- Financial difficulties of SMEs in general
- Possibly: substitution of capital for skilled labour, thus lowering the average salaries and wages

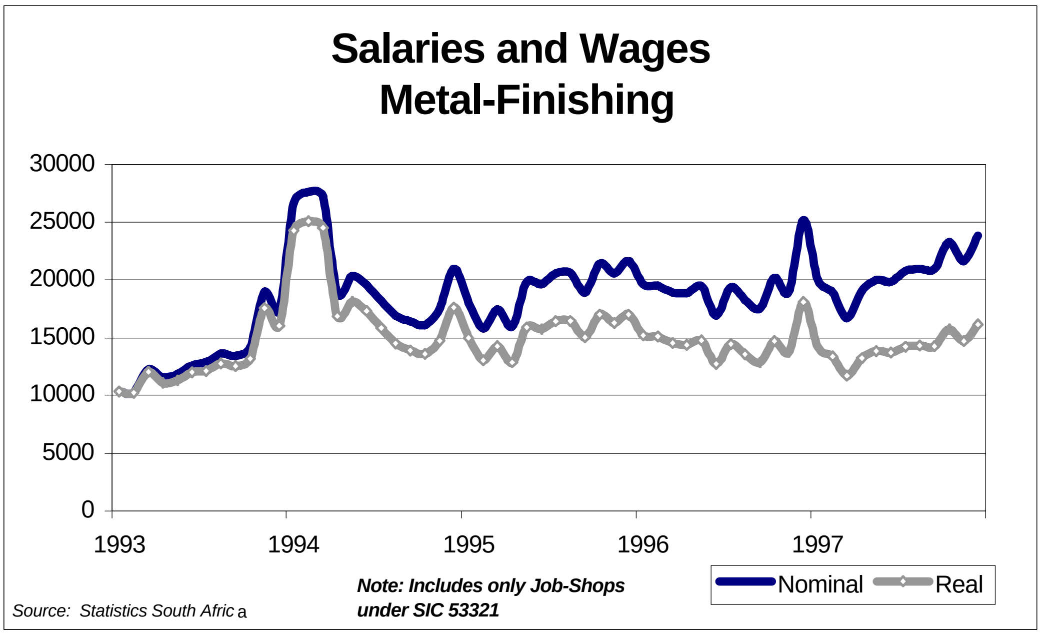

Figure 3-4: Metal finishing industry salaries and wages

3.6 Raw Material Use and Costs

The cost of material inputs obviously has a strong and direct effect on the price of an industry's outputs, together with other costs such as machinery and equipment overheads and labour costs. Inputs as used in this context refers mainly to chemicals and metals used in the metal-finishing industry, as well as other variable input costs such as water and electricity.

The cost of chemicals (especially proprietary cleansers) and metals is the greatest input cost. Labour still accounts for approximately 30% of the production cost (energy and water being relatively minor costs around 5% and 1% respectively). This depends on the type of metal-finishing services offered. Hot-dip galvanisers, with their large quantities of costly zinc inputs, generally have a lower percentage labour cost component, while some powder coaters are known to significantly exceed the 30% mark.

3.6.1 Base metal inputs

While most of the metal-finishing industry's raw material inputs are in the form of chemical solutions, it also requires a number of base metal inputs for use as anodes in electroplating, or to be used in molten form (e.g. zinc for hot dip galvanising).

Most raw materials (metals) are traded internationally, and are thus generally denominated in US $ (or equivalent) prices (although transport costs may affect the final settlement price slightly). This exposes the local industry to the benefits and costs of currency fluctuations and world prices, and may or may not work in the industry's disfavour. A particularly interesting example is the local supply of zinc. Although South Africa is a very insignificant producer of zinc in terms of world wide production (1% in 1997), it is able to produce enough to satisfy local demand. The (almost) exclusive local producer (*Zincor)* is able to export what it does not sell locally at a value just below the cost of most zinc imports, and is fiercely protective of its market dominance. Should the *Gamsberg* zinc mining project (zinc mine, concentrator and refinery, with 300.000t zinc p/a output) be given the 'green light' (in October 2000), *Zincor* would loose its zinc monopoly in the South African market, to the benefit of the galvanising and electroplating industries. While zinc prices may not be very different between the two, the savings to especially the Western Cape metal finishers should be significant due to the lower transport costs and greater supply flexibility.

There has been a general, long-term decline in the value of the ZAR against most international currencies, meaning that this has had a progressively negative (in the sense of becoming more expensive) direct effect on raw material prices. It would seem likely that any downward movement (in **$** terms) of metal prices is unlikely in the longer run, especially as demand from China and India grows (thereby putting upward pressure on international prices). On aggregate, raw material input prices relating to heavy metals are set to further increase into the short term, and especially in the medium to long term. Table 3-6 shows average price developments of metals over the past decade, all of which are directly or indirectly used by the metal-finishing industry. Where they are not being used directly (e.g. hot-dip galvanising processes which uses significant quantities of zinc, or nickel used in electroplating), they would indirectly have an influence on the price of metals in chemicals, which are used extensively during electroplating and galvanising. As can be seen, all metal prices have increased in price during the past decade, some significantly, whiles others have only changed marginally.

Table 3-6 : Metal prices in South Africa

South African Sales Prices of Raw Material Inputs [Metals: ∅ Rands / t *F.O.R* y]					
	Aluminium	**Copper**	**Lead**	**Nickel**	**Zinc**
1990	5.620	6.982	1.531	22.831	3.991
1991	5.678	6.577	1.413	21.984	3.075
1992	5.673	6.555	1.388	20.081	3.545
1993	5.498	6.554	941	15.997	3.151
1994	5.843	8.107	1.164	19.276	3.495
1995	7.510	10.919	1.792	28.277	3.857
1996	7.311	10.074	2.122	32.194	4.332
1997	8.291	11.104	n/a	29.969	6.110
1998	7.500 x	9.500 x	2.950 x	30.000 x	5.600 x
1999	8.420 x	10.500 x	3.050 x	42.000 x	7.200 x
2000 z	10.100	11.000	2.800	66.500	7.250

Notes: **y.** Free on Rail; **x.** *Source*: Approximation based on LME data and US$/R e-rates. (Average annual prices);
z. Refers to Actual Prices on *London Metals Exchange* at End of February 2000, using exchange rate 1 US$ = ZAR 6.45

As can be seen from Table 3-7, the most common metals consumed in terms of pure quantity are ("impure") Zinc ($Zn^{2/4}$), followed by Copper, Nickel and ("pure") Zinc (Zn^{1}) in the ratio [23 : 1.9 : 1.3 : 1]. It should be noted that both the highest consumed metal (anode), being Zinc, as well as the 3rd highest, being Nickel, have either seen vast price increases in the recent past (1998 / 1999), or are likely to significantly increase (further) in the short to medium term. This is becoming obvious in terms of Nickel, and is set to be followed by Zinc when world-wide Zinc capacity starts decreasing, with a number of Zinc mines set to run out of reserves in the next 5 years (Dworzanowski, 2000).

Table 3-7 : Actual plus estimated consumption of metals in the South African Metal finishing industry

Actual plus Estimated Consumption of Metals in the South African Metal-Finishing Industry (p/a)*,** **** Refers to Metal Anodes for Electroplating, other than Zinc$^{2/4}$ for Galvanising*** ***** Excludes the Antimonial Lead / Lead-Tin Anodes used for Chrome Plating (non-consumable)***			
Metal	**Qty p/a**	**Metal**	**Qty p/a**
Cadmium (Balls)	12.720 kg	Zinc^{1+} (Ingots)	357.600 kg
Cadmium (Sticks)	840 kg	Zinc$^{2/4}$ (Ingots)	8.172.000 kg
Nickel (25x25mm chips)	369.480 kg	Copper slugs (High Cond.)	530.880 kg
Nickel (100x100mm squares)	4.680 kg	Copper slugs (PDO)	36.900 kg
Nickel (strip)	33.660 kg	Copper ovals (High Cond.)	60.000 kg
Tin (Ingots)	6.240 kg	Copper Ovals (PDO)	72.000 kg
Tin (Strip)	24.660 kg	Brass Anodes	36.000 kg
Tin – 10% Lead	4.800 kg	Lead Anodes	1.200 kg

3.6.2 Metal-containing chemicals

The majority of metal-finishing industry input materials are in the form of chemicals, both dry and in solution. Table 3.8 shows estimates of total consumption in South Africa of the plating chemicals used with metal anodes, and is based on actual sales and estimates gathered by industry sources.

Approximately half the chemicals sold by suppliers to the metal-finishing industry are sourced from overseas (esp. from Europe and the Far East), and are thus prone to exchange rate fluctuations.

3.6.3 Water

The metal-finishing industry uses water abundantly, especially for rinsing purposes between various plating processes, and of the final product. As rinsing forms a vital step in the plating process, a significant increase in water prices (as discussed at length in section 2.6.2) will lead to higher operating costs and lower bottom-line profits.

3.6.4 Energy

Of the total electricity supplied to South African consumers, approximately 46 % is used by the manufacturing sector. This is by far the largest consumption sector, followed by the mining and residential sectors, each accounting for 20 % of electricity consumed (NER, 1996). The metal-finishing industry is a relatively extensive user of electricity, and thus has the cost of electricity (discussed in section 2.6.3) as an important co-determinant of variable input costs.

Table 3-8: Quantities of chemicals used in the South African Metal finishing industry

PROCESS	CHEMICALS	ESTIMATED VOLUMES / QTY per ANNUM
Nickel	Nickel Sulphate	84.000 kg
	Nickel Chloride	42.000 kg
	Nickel Sulphumate	24.000 kg
	Boric Acid	36.000 kg
Copper & Brass	Copper Sulphate	84.000 kg
	Copper Cyanide	96.000 kg
	Sodium Cyanide	480.000 kg
	Brass Salts	?
Tin & Tin / Lead	Tin Sulphate	12.000 kg
	Tin Chloride	96.000 kg
	Sodium Stannate	480.000 kg
Lead & Hard Chrome	Chromic Acid	456.000 kg
Zinc	Zinc Cyanide	36.000 kg
	Zinc Chloride	36.000 kg
	Sodium Cyanide	Included in Cu
	Sodium Chloride	?
	Ammonium Chloride	72.000 kg
	Sodium Dichromate	66.000 kg
	Zinc Oxide	?
Cadmium	Cadmium Oxide	?
	Sodium Cyanide	Included in Cu
Surface Treatment & pH Control	Sulphuric Acid	420.000 kg
	Hydrochloric Acid	648.000 kg
	Nitric Acid	96.000 kg
	Potassium Cyanide	36.000 kg
	Sodium Hydroxide	144.000 kg
	Caustic Soda	?
	Ammonium Hydroxide	?
	Calcium Hypochlorite	?
	Sodium Hypochlorite	?
Effluent Treatment	Sulphuric Acid	312.000 kg
	Sodium Metabisulphite	144.000 kg
	Sodium Hydroxide	660.000 kg
	Sodium Hypochloride	144.000 kg

3.7 Challenges and Opportunities Facing the Metal Finishing Industry

3.7.1 Small enterprise constraints

The past few years have seen a change in focus of government policy with more emphasis being placed on small business development and support. A greater focus on SMEs is likely to have as a consequence that smaller, independent metal-finishing enterprises will grow at a greater rate than the larger captive operations.

3.7.2 Efficiency and organisational trends

Parallel to the greater emphasis currently being placed on SME development is the trend of *outsourcing*. As complex organisational structures and bureaucracy often place burdens on efficiency gains, improvements in efficiency can often only be achieved by outsourcing certain operations to independent contractors. These outside enterprises have a greater likelihood of achieving economies of scale, and specialising in this particular field.

Captive-shop metal-finishers have become part of a (manufacturing) sector that is exposed to global trends on an increasing scale, meaning the need for innovation, efficiency gains, quality of output and possibly environmental compliance has become much more important.

3.7.3 Raw material developments

Section 3.6 showed that the costs of some of the raw material inputs, most notably nickel and many of the proprietary chemicals (brighteners etc) have increased significantly recently (1999 / 2000), both in US $ terms and especially in Rand terms. While pushing up input costs, only a limited portion of these costs can be passed on in the form of output price-increases (Zolk, 2000). This forces metal-finishing enterprises to continuously investigate means of improving operational efficiency.

3.7.4 Water and energy

Water and energy prices, whose price movements significantly affect the industry, are likely to change in both the medium and long term. However, their price changes are expected to take on opposite direction, with the price of water expected to rise sharply, and energy costs possibly decreasing further (in real terms).

3.7.5 Costs of investment

The metal-finishing industry has a very low ratio of investments to turnover (4.3% for the manufacturing sector as opposed to 2.4% for the metal finishing industry). The low ratio could point to the fact that capital expenditure is generally not as urgent as for example in a high-technology environment (where obsoleteness occurs much more rapidly).

The cost of capital has been one of the major impediments to investment into more efficient, and often more environmentally ‘friendly’ technology. The high interest rates may have, ironically, given the larger (and often more efficient) metal-finishing enterprises a slight comparative advantage due to their relative financial / capital strength, and they may have invariably captured some market share from smaller firms. On the general up-side, interest rates have been decreasing steadily since late 1998, and by February 2000 reached the lowest levels in 14 years.

However, where financial institutions *perceive* the risk of lending to SMEs to be high, they may charge interest rates that far exceed their prime rate. Often this *perceived* risk is based on ignorance on behalf of the financial institutions.

In the many cases that short-term payback periods are required, these high interest charges make the new-investment costs prohibitive. While organisations such as the *IDC* usually offer rates at below the prime interest rate, the average finance required by the metal-finishing industry would fall below the minimum loan amount that is stipulated by this institution.

3.7.6 Environmental performance and pressure on compliance

Some of the most serious challenges facing the metal-finishing industry are the advances made in the legislative framework governing the environmental performance of South African enterprises, as well as pressure from up and down the supply chain to improve environmental performance.

No longer will firms be able to impose an unnecessarily high burden on the environment without being liable for their actions. Disposal methods used for industrial waste will be increasingly closely monitored, and the costs involved will take account of the environmental and economic burden to a much greater extent.

Pressure on environmental compliance will not only emanate from a local legislative point of view, but will also stem from a variety of other sources. These include both local and international consumers as well as employee organisations. Local consumers will increasingly follow the international trend of demanding environmental compliance and minimum procedural, quality and administrative standards, especially where they themselves subscribe to minimum standards. Where clients of metal-finishing enterprises have, for example, ISO 9000 (quality management) and ISO 14000 (environmental management) certification, they may be hard-pressed to pass stringent environmental demands and minimum quality standards on to their suppliers. ISO 14000 hopes to achieve *environmental* standards similar to the *quality* standards achieved by ISO 9000. While such stringent certification is more prevalent amongst international enterprises and large local firms than among smaller enterprises, their (SMEs') involvement in the supply chain nevertheless indirectly exerts similar pressures on their operations. Especially amongst the larger captive metal finishers, as well as the independent job-shops, a very real challenge exists to evolve and grow in terms of efficiency and environmental compliance. Failing this, especially the SME portion of the metal-finishing industry will find it difficult to remain sustainable in the long run.

4 Opportunities for Waste Minimisation at the Company Level

4.1 Introduction

In accordance with the original project objectives, much attention was focussed on the gathering of data at the company-level. Waste minimisation opportunity assessments were selected as a useful tool to simultaneously collect data on physical flows of material and energy, and assess the extent to which environmental improvement in individual manufacturing entities was possible. Such improvement, it was hypothesised, could be realised either by the company acting alone, or through some form of symbiotic, or co-operative behaviour. This chapter presents the opportunities found, and discusses them in these two categories.

4.2 The Identification of Improvement Options

The identification of improvement options was done with a methodology based on the original U.S. EPA Waste Minimisation Opportunity Assessment Manual (Freeman, 1988), adapted after experiences in the Dutch PRISMA project (Dieleman et al., 1991; de Hoo et al, 1990), and further adapted based on European experiences de Hoo et al., 1991; Kothuis and van Berkel, 1992).

The assessment methodology is based on the principle of looking for the *source* and the *cause* of wastes and emissions that are generated by a company. To do this, a procedure is followed that helps to identify the improvement opportunities (see section 4.2.1), using five generally accepted Prevention Techniques (see section 4.2.2).

Beyond the application of these waste minimisation techniques, the project aimed to investigate opportunities for improved environmental performance in the larger manufacturing systems. This is discussed in chapter 7.

4.2.1 The waste minimisation opportunity assessment procedure

The methodology as used in this project comprises of the following four stages:

- The *planning and organisation* of the assessment in the company. This required getting management commitment in order to prevent early abortion of the project, and increase the chances for identification of successful improvement options.

- The goal of the *pre-assessment phase* is to select focus areas. All in- and outgoing material flows are identified. This means that all raw materials, and all waste streams and emissions are identified and marked on process flow sheets. The quantities of all flows are established based on readily available data and educated guesses. Total environmental costs are allocated to the waste streams (including losses of raw materials, handling costs, loss of added value, treatment costs, disposal costs, charges, fines etc.). Mass balances are made on company level to establish anomalies or unknown flows (e.g. leaks). During this process the first improvement options are sometimes already identified. Since these are often simple by nature, they can be immediately implemented. These ‘early successes’ can increase the company’s motivation to continue. The preassessment phase is concluded with an overview of the companies material flows and environmental costs, and with a selection of focus areas for the assessment phase.

- The *assessment phase* is to lead to a range of improvement options by gathering additional data about the selected processes or waste streams. In this phase, laboratory analyses, flow measurements and detailed mass balances of specific processes are made. The goal is to identify the exact source and cause of the selected inefficiencies. Once these are known, improvement options can be identified from literature and by brainstorms in the companies. During this brainstorm, employees from all levels are involved, as well as network partners that may have a valuable contribution to identify options for the selected focus areas.

- The *feasibility analysis* entails technical, economic, and environmental evaluation, of a selection of the identified options to establish if they can be implemented without negative effects on the environmental of economic performance of the company.

Improvement options can be identified during all stages of the assessment procedure. Figure 4-1 gives an overview of the relationship between focus areas, improvement options and improvement measures generated during the assessment procedure (adapted from van Berkel et. al., 1991).

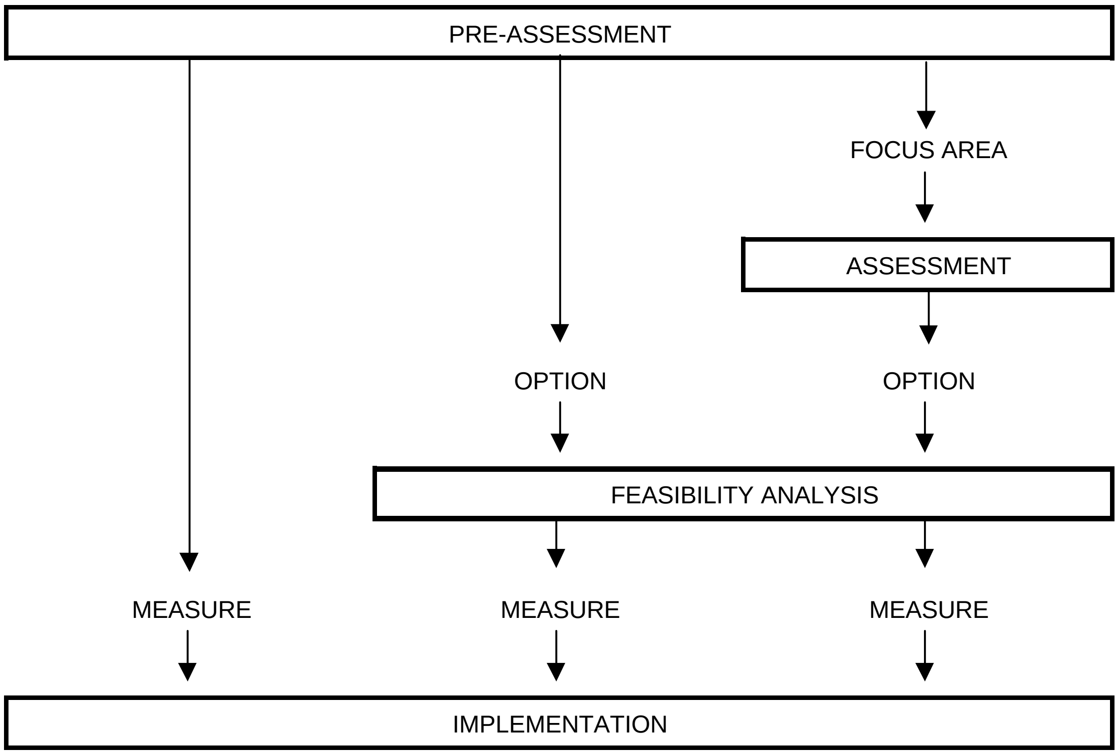

Figure 4-1: Relationships between the different assessment phases

Structured worksheets were used to gather information in the pre-assessment phases in the companies. Most of this waste minimisation methodology work was done by senior undergraduate or Masters level students who spent various times in the companies. An example of the worksheets is included in Appendix 4.

The detail and focus of the waste minimisation assessments in the companies varied. This was dependent on number of factors such as the experience and dedication of students involved, the time spent in the company, the co-operation and involvement of the company, main environmental issues of the company, size of the company, complexity of the company's production process, and the company's preferences for focus areas.

Therefore, in some companies, more intense assessments were done than in others, and consequently, different number of options were found in the different companies. A formal brainstorming session with involvement of employees, the project team, and 1 or 2 outside experts was organised in 4 companies and increased the number of identified options in those companies. An overview of the involvement in the assessments in the companies is given in Table 4-1.

Complete Waste Minimisation Opportunity Assessments (as in the PRISMA or US-EPA methodology) involve two more phases than described above. The feasibility assessment phase is followed by the *implementation phase* in which implementation plans are drawn for the feasible improvement options. After the implementation phase, the *continuation planning phase* starts focussing on remaining wastes and emissions and makes sure that the preventative philosophy is ankered within the organisation. This often leads to opportunities to implement more formal environmental management systems suchs as ISO 14000 etc.

Such complete full waste minimisation opportunity assessment were not performed in this project since implementation of the feasible options and realisation of a continuous preventative environmental management system in the participating companies was not part of the project. However, as mentioned in chapter 1, the companies were only willing to co-operate if there was benefit for them in the form of identified feasible improvement options. Therefore, the feasibility analysis was the last phase of the project.

Table 4-1: Involvement in the assessments in the company

	MSc student (months in company)	Senior undergrad (months in company)	Internat. exchange student (months in company)	Network assessment (months in company)	Total no of months in the company	Brainstorm done	No of options identified
M1	24 (*)	2		3 (*)	29	Yes	33
M2	24 (*)	-	-	-	24	yes	42
M3	-	2	8		10	No	6
M4	18 (*)	-	-	-	18	No	6
M5	18 (*)	-	-	-	18	No	11
T1	-	2	5 (*)	3 (*)	10	Yes	21
T2	-	2	-	-	2	No	7
T3	18 (*)	-	-	-	18	No	10
T4	-	-	5 (*)	-	5	No	28
T5	20 (*)	2	-	-	22	Yes	17

(*) Student was involved in 2 companies

By the end of the project, three of the ten companies had not reached the stage where complete assessment phases and feasibility analyses were finalised. All other companies had finished the waste minimisation assessment and feasibility analyses phases, although there were differences between the companies in the depth and detail of the analyses. At the end of the project, a total of some 180 options had been identified, of which 96 were assessed to be feasible, and 32 thereof had been implemented.

Table 4-2: Focus areas, options and measures in the 10 participating companies

	focus areas	options	measures	Options to measures
M5	5	11	1	(*)
T2	3	7	1	(*)
T3	3	10	1	(*)
M1	6	33	2	
M2	5	42	8	
M3	1	6	2	
M4	4	6	4	
T1	2	21	9	
T4	2	28	3	
T5	2	17	1	
TOT	33	181	32	18%

(*) assessment and feasibility incomplete

4.2.2 The five prevention techniques

The identification of improvement options is done with the five so called ‘Prevention Techniques’ in mind. These techniques are also called the five source reduction techniques. They represent the top tier of the waste management hierarchy.

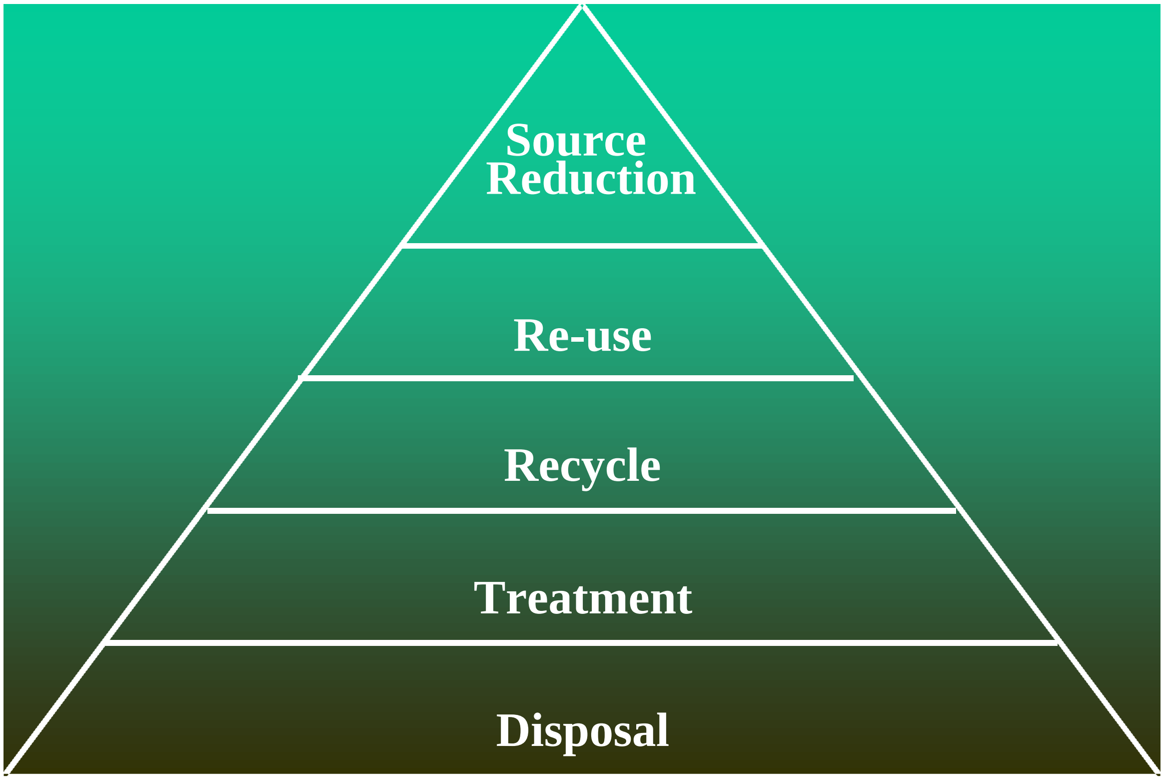

Figure 4-2: Waste management hierarchy

Product change leads to changes in the properties of a product, such as the shape of the product or material of which it is made. The new product has a longer lifetime, can be easily recycled or can be produced with less polluting` production processes. Changes in packaging materials are also seen as product changes.

Changes in raw material input include the use of less hazardous raw materials (reduction in toxicity of waste streams), or a reduced consumption of raw materials (reduction in volume of waste streams).

Technology change means automation, process optimisation, use of a new technology to produce the same product, or changes in the layout of the company. Examples are the change from a filter system with disposable filters to a filter system with re-usable filters.

Good housekeeping includes a range of changes in procedures, instruments, or in the organisation that prevent the generation of wastes or emissions. For example delegation of tasks and responsibilities, changes in measuring and registration procedures, or changes in work-procedures. Setting up a registration system that prescribes all employees to note down all chemicals when used, not only provided insight in consumption patterns but also leads to increased awareness and reduced consumption of chemicals.

The last prevention technique is **internal reuse**. This means the reuse of materials from waste streams within the company where they originated. Waste streams can be directly reused as raw materials, after re-winning or treatment or re-winning of chemicals or used somewhere else in the production process. Examples are the reworking of an off-spec batch to second grade product, treatment and recycling of water, re-winning of heavy metals from process baths etc.

Although **external reuse** is strictly speaking not a prevention technique (falling into the second level of the waste management hierarchy), it certainly can increase the eco-efficiency of companies that apply it. In this project we included this technique because it requires co-operation between network partners (industrial symbiosis) and is the first technique to be considered after source reduction.

4.3 Analysis of the Identified Options

The identified improvement options were analysed to see how the different prevention techniques were applied, and how many of the options require co-operation from different categories of network partners.

4.3.1 Division of the identified options over the prevention techniques

A total of 181 improvement options are identified in the companies. This averages to 18 options per company. As can be seem in Figure 4-3, most of the identified options are either good housekeeping options or technology changes, followed by options involving internal recycling, changes of input material and external recycling. It must be noted that energy efficiency fell outside the scope of this project and therefore no energy related options were identified.

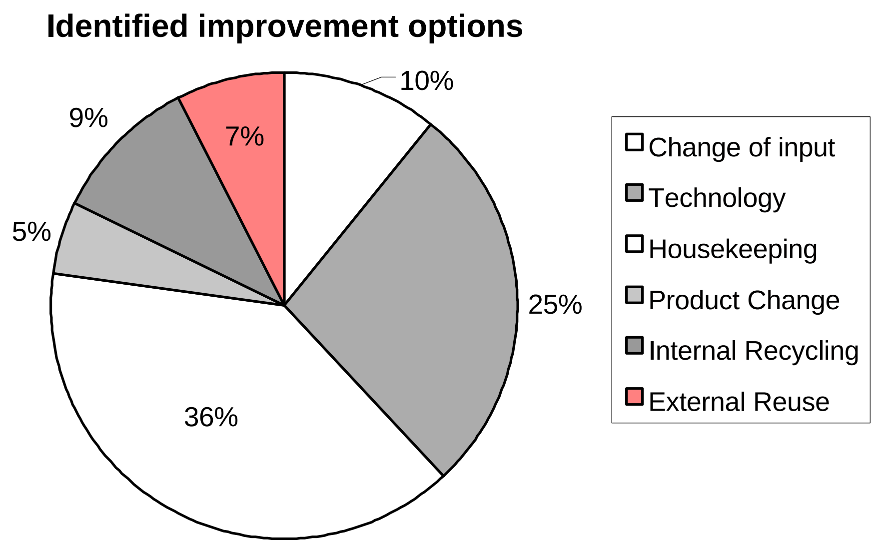

Figure 4-3 Classification of the identified improvement options by the prevention techniques

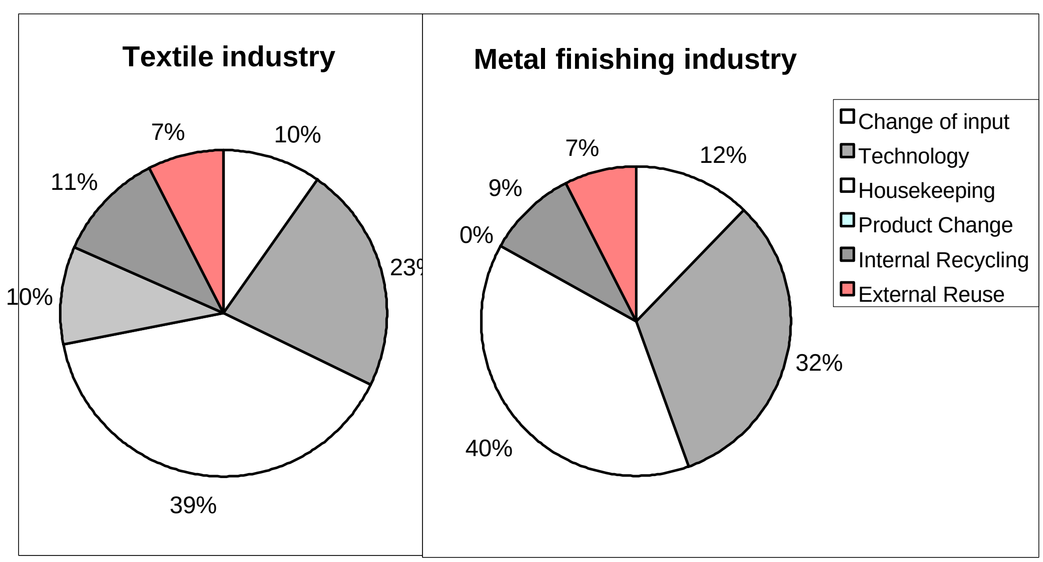

Figure 4-4: Classification of the identified improvement options by the prevention techniques for the two industry sectors

4.3.2 The role of co-operation in implementing identified improvement options

The completion of waste minimisation assessments was not only intended to gather further evidence in support of a basic premise of this project, viz. that there is a greater need for better environmental management in the SME dominated South African Manufacturing industries. It also had to gather data in such a form as to allow the main research premise to be investigated. This premise states that efforts to improve co-operation and foster symbiosis-like relationships would form an essential part of any strategy to improve the environmental profile of these sectors. The identified improvement opportunities were analysed in this light.

Not for all improvement options is co-operation with an outside partner necessary. Some of the options can be done by a company by itself. This is often the case for the more simple good housekeeping options.

For other improvement options, co-operation between a company and its outside partners can be necessary when implementing the option. We distinguish seven categories of partners that might be able to assist in the implementation. Table 4-3 shows these seven categories.

Table 4-3: Categories and subgroups of partners

Category	Subgroups
Suppliers	Suppliers of materials Suppliers of technology
Clients	Direct clients Clients of clients End users
Service providers	Waste management companies
Other companies	Colleagues / competitors Neighbouring companies
Government	Local / provincial National
Financial institutions	Banks Shareholders
Support organisations	Research organisations Consultancy organisations Industry organisations Employer organisations Employee organisations (unions) Training organisations

If co-operation is needed, then two types of co-operation can be distinguished:
- essential co-operation, where an option cannot be implemented without the partner, and
- supportive co-operation, where support from the partner facilitates implementation but is not essential for implementation

We analysed all identified improvement options for three questions:
a) Does the company need assistance to implement this option?
b) Is the assistance essential, or is it supportive co-operation?
c) If co-operation is needed, which partners can provide the needed assistance?

The need for co-operation is of course company specific. Where company A could be very well able to implement a certain option by itself, company B might need assistance with implementing this option. All options were analysed for the situation in the specific company where the improvement option was identified.

We found that for 64% of the 181 identified improvement options, co-operation with a network partner is necessary. This means that 36% of the identified improvement options can be implemented by the company on its own.

We were interested to see what type of partner was most often needed for the cases where co-operation was necessary. Therefore we analysed all identified improvement options for potential for co-operation with the categories and subgroups of partners from Table 4-3. The results are given in Table 4.4.

As can be seen in Table 4.4, most of the co-operations that were needed, where with suppliers. This relates to both suppliers of technology and suppliers of raw materials and chemicals. Many options that involved changes of input materials, needed co-operations with both chemical suppliers as well as suppliers of equipment.

Table 4-4: Type of co-operation needed to implement options

suppliers	50%
other: colleagues/competitors	6%
government	5%
financial institutions	2%
clients	8%
service providers: waste	6%
support org.: industry organisations	6%
support org.: research/consult/training	18%

In only 4% of the cases co-operations with government were essential or supportive. The only option were there was need for supportive co-operation with government was the option of monitoring of water consumption. The local government can play a supportive role by providing extra information with the water bills. The limited need for co-operation with the government can be explained by taking into account the dynamics of changing industrial attitude to environmental matters. There are different phases in the process of increasing eco-efficiency of SMEs where co-operation is needed. Different partners are needed in the three main stages:

1) First a company needs to become aware of the need for improved eco-efficiency
2) Once the company is convinced of the need for improved environmental performance, the company will need assistance in how to identify improvement opportunities.
3) After the company has found improvement options, it will need assistance in implementing the feasible options.

1) Raising awareness

Governments for example can play a major role in facilitation of the awareness raising activities via industry organisations, consultants, suppliers, etc. The role that the different governmental organisations can play is given in Table 4-5.

Table 4-5: Possible roles and responsibilities for Cleaner Production (World Bank, 1997)

Partner	Upgrading Existing Industry	Influencing Future Investment Towards Cleaner Production
Environment Ministries	Establish environmental objectives; design regulations; negotiate sector agreements.	Establish clear framework of long-term environmental objectives and requirements.
Industry Ministries	Mobilize sectors and identify necessary resources.	Identify and promote appropriate technology; support improvements in management.
Finance Ministries	Review resources pricing and incentives; support discharge fees and similar instruments	Consider environmental objectives in designing fiscal instruments for industrial promotion.
Local Government	Negotiate site specific agreements which address environment, employment and local concerns within a sector framework.	Ensure that infrastructure exists which encourages cleaner industry to locate (waste disposal and recycling, educated workforce etc.).

2) Identifying improvement opportunities

The assistance in identifying improvement opportunities is typically the role of industry organisations, research and Consultancy organisations and suppliers of technology and raw materials. The assistance of colleague companies in this process depends on the degree of organisation and co-operation of the industry sector.

3) Implementing improvement options

The implementation of new technologies will mostly be assisted by the supplier of the technology. In some cases (mostly with the 'softer' management related issues) a training or consultancy organisation can assist. Financial institutions can also assist in facilitation of implementation by providing special programs for cleaner technology investments. Of course, all involved parties in the specific improvement options need to assist in the implementation phase. For example, if the option involves changes in the product or packaging, then the client may have to co-operate in the test phases of the implementation, or if the option involves new ways of waste separation and collection, then the waste management company may have to co-operate in the implementation phase.

4.4 Conclusion

A large number of options were identified that could improve the eco-efficiency of the 10 participating companies. 18% of these yielded into feasible measures during the project lifetime, improving the eco-efficiency of the case companies. This is in strong support of the conclusion in previous work (e.g. EMG, 1993) that there is a need for better environmental management in the two studied sectors.

A large fraction of the identified improvement options were of the relatively simple good housekeeping options that are easy to implement and need little assistance. However, there are also many improvement opportunities that need, or benefit from co-operation between SMEs and their network partners. This is mostly the case for the options that involve changes in technology, raw materials or products. Most of the co-operations are of an essential nature, which means that without co-operation with the network partner, the improvement option cannot be implemented. The network partners that were most needed for implementation of improvement options in the companies in this project are the suppliers of technology and raw materials, and, to a lesser extent, the clients. This means that for many companies supply chain management concepts may be interesting to look at first when considering different environmental management tools.

From the work presented in this chapter, it can thus be concluded that one of the premises proposed at the outset of this study, viz. that co-operation of individual companies with outside entities can lead to increased well-being of the company, and to more efficient production, at least at the company-level, has been substantiated. Nevertheless, it must be recognised that much of this co-operation is of a "change" nature, i.e. it is needed to propel the company from one state to another, rather than being a continuous "symbiotic" relation, whereby mass and energy flows are continuously interchanged.

The following two chapters will continue the presentation of our analyses at the company level, looking at company management (i.e. species characteristics) as a determinant of capacity to change environmental performance in manufacturing SMEs, and at company "economic health" as a factor influencing the ability of individual companies to effect change. Thereafter, in chapter 7, attention will be re-focussed on improvement options requiring co-operative approaches, and how their exploitation relates to a systematic optimisation of environmental performance in larger production systems.

5 Management Assessments

5.1 Introduction

One of the central questions of the research project was whether SMEs have the management capacity needed to effect constructive change in their overall performance by themselves. To answer this, our research investigated what aspects of management the case study SMEs were specifically good or bad at. In this chapter we present our results specifically on issues such as willingness, intent and capacity of companies to co-operate with other companies, which are essential if the identified potential for Industrial Symbiosis as discussed in the previous chapters is to be harnessed. These issues are largely determined by the management style and company culture of a company.

5.2 Background to the Methodology Development

It is suggested that to determine the degree to which companies can successfully participate in an industrial symbiosis network, some assessment of the 'soft' issues (company attitudes, willingness to participate, etc.) needs to be undertaken in addition to the 'hard' issues (finance, technical capabilities). With help from African Environmental Solutions (AES), the South African representative of Arthur D Little International Inc. (ADL), an assessment tool was developed in the form of a short questionnaire which would provide some form of quantifiable insight into these softer issues.

The foundation for the assessment tool was first centred around the concept of 'corporate culture'. A brief review of literature on corporate culture soon identified that the categories and areas typically assessed by techniques in the literature were not directly relevant to the goals of this project. The literature on company culture commonly refers to four basic types of company cultures - Role, Power, Achievement and Support types (although a variety of different names and interpretations exist). The characteristics typically considered as relevant in identifying a specific culture (e.g. organisational structure, means of control, implicit values, motivation, etc.) were thought to be of interest, but not useful in distinguishing between companies as required by our project. In short, it was felt that the presence of a particular type of culture (or a varying mix of cultures) did not *a priori* determine the degree to which successful participation in the industrial symbiosis network could be expected.

A second foundation for the work was sought in the work of ADL in the field of 'change management'. ADL has published techniques on identifying "The Unwritten Rules" which govern and cause conflicts within an organisation (Scott-Morgan, 1994) These techniques centre on finding the important motivators, people and evaluation procedures in an organisation which drive the business.

The ADL method depends on seemingly unstructured interviews (from the interviewees point of view, that is) in which questioning is used as a vehicle to elicit the opinions and insights of the interviewee towards the organisation. The view and opinions of different interviewees are compared, searching for consistency and the underlying themes which in effect constitute the 'unwritten rules'. An important aspect of the technique is to focus the interviews around specific issues of relevance to the problem at hand.

The ADL methodology could not be directly applied in this project because its aims are significantly different from what was required in this project. The ADL method is intended to identify the 'unwritten rules' with a view to using or modifying the rules to address a specific business problem within an organisation, then in a structured way, to assist the organisation in solving the problem. In the case of our project, the requirement is far less ambitious, namely to assess and evaluate issues related to implementation of an industrial symbiosis program, without necessarily trying to assist the organisation.

The development of the assessment tool is discussed in the following section.

5.3 The Methodology

The first step in the development of the methodology was thus to adapt the appropriate elements from the work of ADL and others, and to synthesise an assessment tool suited to the needs of the project. The resulting methodology loosely followed the ADL structure.

The different steps of the methodology are given in Table 5-1.

Table 5-1: The management assessment interview methodology

1.	Identifying the ‘soft issues’ in the form of key aspects considered to be of relevance
2.	Structuring a set of questions around the key aspects
3.	A series of interviews about the key aspects were done at each company
4.	Under each of the headings, the key aspects were subjectively rated by the interviewers
5.	Application of the rating methodology led to a final rating for the company on each of the key aspects.

5.3.1 The key aspects

The key aspects relevant to the acceptance and utilisation of Industrial Symbiosis practices by South African SMEs have been grouped into the three broad headings of Values, Intent and Capacity.

Values - do the core principles of the company suit those necessary for an industrial symbiosis program?
Intent - does the company have the willingness to undertake the work necessary to make an industrial symbiosis network a success?
Capacity - does the company have the ability to undertake the work necessary to make an industrial symbiosis network a success?

Each element was characterised by a number of keywords. These keywords provided the interviewers with support during the interviews, but especially when rating each of the aspects after the interview.

5.3.2 The set of questions

The set of questions was based on the key aspects and is attached in Appendix 5.

The interviews started with a series of ‘background’ questions, intended to be simpler and less open ended, to put the interviewee at ease for the subsequent questions as well as provide a measure of information transfer within the company. This followed by a set of questions that revolved around the keyword and was grouped by the three headings (values, intent and capacity).

5.3.3 The interviews

The project leader and the AES representative held loosely structured interviews with representatives from the company, using the questions as a basis for discussion.

For each participating company, interviews were done with a total of 3 to 5 individuals. Each interview lasted between one and two hours only, so that the interviews could be completed in one day in the case of a smaller company, and in two days in the case of larger companies.

The interviewed people were selected from different levels within the organisational hierarchy and varied from the owner/MD, the bookkeeper, the receptionist, or the quality manager, to machine operators.

Table 5-2: Key elements required within an organisation to implement industrial symbiosis

Element	Keywords
Values (‘attitudes’)	
Responsibility towards the environment	recycling, waste, community, place on ‘evolutionary ladder’
Go the ‘extra mile’	overtime, donations, involvement, dedication, loyalty
Seek out new possibilities (outward looking)	liaisons, new products, new markets, recent changes, benchmarking against others
think of the long term	history, company myths, planning, strategy
wanting to learn	training, mistakes, failures, successes, information, keeping current, best practices
cohesiveness within the company	communication, sense of direction, vision, stability, working together
Intent (Are they willing to . . .)	
innovate / experiment (with production process, as well as systems)	changes to process, age of equipment, number of different products, markets, deadlines, stock
disclose information about company to external parties	relationship with community, competitors, trade secrets, public relations, things to hide
commit human and financial resources	time, people, money, profit or loss, consultants, training, commitment
take risks	chance, change, pressure, uncertainty, unknown, opportunity
form informal partnerships and alliances	alliance, partnership, work together, groups, associations, sharing, memberships
Capacity (Is there the ability to . . .)	
know techniques for improving environmental performance	waste minimisation, EMS, cleaner production, recycling, substitution, monitoring, planning, env. management
know / understand the production process: • key parameters and influence thereof • quantity and quality of material and energy inputs/outputs	technical ‘know-how’, modify, consequences, back-up, information, search, benchmark, common practice, amounts, type, contaminants, values, measurement, monitoring, checking
innovate / experiment (with production processes as well as systems)	changes to process, age of equipment, number of different products, markets, deadlines, stock, expert, foreman, engineer
disclose information about company to external parties	relationship with community, competitors, trade secrets, public relations, things to hide, head office, Board, previous experiences
commit human and financial resources	time, people, money, profit or loss, consultants, training, commitments, other work, organisation
get the ‘key people’ on board	communicate, agree, delegate, harmony, ‘old-timers’, sell
deal with the change (e.g. morale, ‘saturation level’)	other initiatives, legal compliance, stress, satisfaction, capacity, slack, overtime, motivation
deal with external pressures/constraints	relations with customers and suppliers, neighbours, typical practice in industry, proactive or reactive, leader or follower, contacts with others in the same business

5.3.4 The rating of the aspects

The result from the different interviews in the same company were compared and discussed between the interviewers to identify common themes and significant differences. Based on the interviews, the interviewers then subjectively rated the key aspects under each of the headings. The method for attributing a rating is based on a 1-2-3 rating system, where in terms of implementing an industrial symbiosis program:

1 represents a desirable state
2 represents an intermediate or ambivalent state
3 represents an undesirable state

5.3.5 Combining of aspect ratings to an overall company rating

First the ratings for all the key aspects were combined into a rating for each of the three headings (values, intent and willingness).

It is acknowledged that each key aspect does not necessarily carry the same weight as others. The assignment of weighting factors to key aspects (and indeed the broader headings as well) is a subjective attempt at making the model more closely represent reality (as perceived by the project researchers). The set of weighting factors and the rating ranges are given in Appendix 6.

The procedure for the calculation of the ratings is given in Table 5-3.

Table 5-3: The procedure for the calculation of ratings for the three headings

1. use the subjective ratings for each key aspect as a starting point;
2. multiply each aspect rating by its associated weighting factor;
3. sum the products of step 2;
4. categorise the total in terms of a 1, 2 or 3 rating as detailed below;
5. determine the minimum possible total within a heading (all aspects rated as 1);
6. determine the maximum possible total within a heading (all aspects rated as 3);
7. divide the interval between the minimum and maximum totals into three equal intervals. If this is not possible, make the middle category the largest;
8. define the interval with the smallest group of values as '1', the second or middle interval as '2', and the final (that associated with the largest numbers) as '3'.
9. assign the rating to the heading under which the aspects fall

From the rating for the three headings, an overall company rating can be derived. The same principles as detailed above are applied at a more general level to arrive at an overall rating for the company. The steps are given in Table 5-4.

Table 5-4: The procedure for the calculation of the overall company rating

1. use the ratings for each heading as a starting point;
2. multiply the rating for each heading by its associated weighting factor;
3. sum the products of step 2;
4. categorise the total in terms of a 1, 2 or 3 rating as detailed below;
5. determine the minimum possible total (all headings rated as 1);
6. determine the maximum possible total (all headings rated as 3);
7. divide the interval between the minimum and maximum totals into three equal intervals. If this is not possible, make the middle category the largest;
8. define the interval with the smallest group of values as '1', the second or middle interval as '2', and the final (that associated with the largest numbers) as '3';
9. assign the final rating of 1, 2 or 3 to the company as a whole.

By tracing backwards into the rating structure for a specific company, one will be able to identify what the problematic resistances are and perhaps plan ways to mitigate their influence on the implementation process.

5.3.6 Validation

After development, the methodology was sent to Dr Max Sully from the School of Management Studies at the University of Cape Town for comment, and was then tested at a company in Cape Town. The test and the comments led to minor adjustments and additions. The main addition was a validation method that was deemed necessary due to the risk of subjectivity clouding the results of the management assessment. This validation methodology introduced a set of independent evidence which can easily be obtained by an external reviewer to check upon the interpretation of the interview as originally performed. It is intended to be used by an external reviewer either:

- in event of a dispute between the assessment team and the company being assessed

- as an intermittent check of the assessment process to ensure that results of the subjective analysis are reflected by verifiable evidence

The validation methodology has not been applied. In two cases a company requested a second visit of the assessment team in order to discuss the outcome of the assessments. These discussions were sufficient to reach agreement on the results.

5.4 Results

The results of the ratings of the companies for each of the aspects is given in Table 5-5.

Table 5-5: Results of the company ratings

Headings and key aspects	Weighting	METAL FINISHING INDUSTRY					TEXTILES INDUSTRY					Average
		M1	M2	M3	M4	M5	T1	T2	T3	T4	T5	
Values	**1**	**2**	**2**	**2**	**2**	**2**	**2**			**2**	**2**	**2.0**
Responsibility towards the environment	1	3	2	3	2	3	2			2	2	**2.4**
Go the ‘extra mile’	1	2	1	1	2	3	1			3	2	**1.9**
Seek out new possibilities	1	1	2	2	2	2	2			2	2	**1.9**
Think of the long term	1	3	3	3	1	2	2			2	1	**2.1**
Wanting to learn	1	2	1	1	1	2	2			2	2	**1.6**
Cohesiveness of the company	1	2	1	1	3	2	2			3	3	**2.1**
Intent	**2**	**2**	**1**	**1**	**2**	**2**	**2**			**3**	**2**	**1.9**
Innovate / experiment with production process	1	2	2	1	2	2	1			1	2	**1.6**
Disclose information about company to external parties	2	2	1	1	2	2	2			3	2	**1.9**
Commit human and financial resources	2	2	2	1	2	2	2			2	3	**2.0**
take risks	1	2	3	2	1	2	1			2	2	**1.9**
form informal partnerships and alliances	2	1	1	1	2	2	2			3	2	**1.8**
Capacity	**2**	**2**	**1**	**1**	**2**	**2**	**2**			**2**	**2**	**1.8**
Know techniques for improving environmental performance	1	3	2	2	2	3	3			3	2	**2.5**
Know / understand the production process	1	2	2	1	1	2	2			2	2	**1.8**
Innovate / experiment with production process	1	3	2	2	2	2	2			2	2	**2.1**
Disclose information about company to external parties	2	1	1	1	2	1	1			2	2	**1.4**
Commit human and financial resources	3	3	1	2	2	3	2			2	2	**2.1**
get the ‘key people’ on board	2	2	1	1	2	2	1			1	3	**1.6**
deal with the change (e.g. morale, ‘saturation level’)	2	2	1	2	2	2	2			2	3	**2.0**
deal with external pressure/constraints	1	2	1	1	2	2	1			2	2	**1.6**
FINAL TOTAL COMPANY SCORE	**-**	**2**	**1**	**1**	**2**	**2**	**2**			**2**	**2**	**1.8**

Eight companies were assessed with the above describe methodology. Two companies were not prepared to undergo such a management assessment. One of these companies withdrew from the project because of a complete change of management focus, the other entered the project in a late stage and they did not have time to allow staff of for the interviews.

From Table 5-5 it can be seen that most of the companies scored an average ‘2’ overall company score, and could be seen as partially suited to participate optimally in industrial symbiosis networks. Only two companies had a ‘1’ total company score and could be considered as ideally suited for participating in industrial symbiosis networks.

5.5 Conclusions

The ratings of the different companies were compared to see what aspects of management differed significantly between companies and/or between sectors.
Based on these results, the following analyses were made:

1. What were the participating companies really good at and what were they bad at.
2. What were the difference between SME's and bigger companies
3. What were the difference between metal finishing companies and textile companies.

Table 5-6 shows some of the conclusions from this analysis.

Table 5-6: Conclusions from the management and company culture assessments

Category and key aspects	Conclusion
VALUES	
Responsibility towards the environment	All companies are bad at this but metal finishing companies are much worse at it than textile companies.
Think of the long term	SME's are much worse at this than big companies, and metal finishing companies are much worse at this than textile companies
Wanting to learn	Metal finishing companies are much better at this than textile companies
INTENT	
commit human and financial resources	Metal finishing companies are much better at this than textile companies
take risks	Metal finishing companies are much worse at this than textile companies
CAPACITY	
know techniques for improving environmental performance	All companies are bad at this but SMEs are much worse at this than big companies
know / understand the production process	SMEs are worse at this than big companies
Disclose information about company to external parties	All companies are good at this but textile companies are still significantly better at this than MFI companies
get the 'key people' on board	SMEs are much better at this than big companies
deal with the change (e.g. morale, 'saturation level')	SMEs are better at this than big companies

It is interesting to notice that most companies score very high on the capacity to disclose information about the company to external parties. This means that there are little restrictions on sharing information with external parties. However, all companies scored much lower on their *intent* to disclose information. This indicates that although companies are able to disclose information, the management is not too eager to do so. This underlines the view that most companies see the other industries in their sector first as competitors, and secondly as colleagues. There is a more closed culture in corporate South Africa. This is amongst others also visible in the number of industry associations in South Africa as compared with more open cultures such as in Western Europe, and in the limited role that most of the existing industry organisations play (mainly as negotiators, and less as technology or "efficiency" advisors to their members).

6 Economic Situation in the Companies

It is often said that a healthy economic situation is a necessary condition for a small or medium company to be able to devote resources to improving its environmental management. This chapter investigates the relationship between the economic health of a company, and the potential for environmental improvement.

In order to explore this hypothesis we evaluated all participating companies on their economic performance and correlated the identified options (see section 4.3) to the economic health of the companies.

6.1 Description of the evaluation method

The economic evaluation of the companies was done according to pre-determined guidelines, and information on various categories contributing to or affecting the company was gathered. While the information obtained was intended to assess the companies from an overall economic perspective, an important underlying criteria was to assess the company's ability to raise capital for continued sustainability of operations and further investment in (and maintenance of) technology and equipment.

Companies were broadly assessed according to 6 main criteria, consisting of (1) market conditions, (2) supply conditions, (3) human resources, (4) technology and formal certification, (5) the companies' present financial situation (which carried particular weight in rating its ability to raise capital) as well as (6) an assessment of the companies future outlook.

These broad categories were evaluated according to a number of criteria, as well as other issues pertaining to a particular company or industry sector:

1. ***Market Conditions***: Intensity of rivalry; impact of exchange rate fluctuations; price and other competitiveness; state of the industry; effect of overall economy and related industries on firm / sector; actual and perceived environmental pressure; (scope) for sales growth, sales steadiness etc.
2. ***Supply Conditions***: Sources of supply and supply arrangements; ability to diversify sources of supply and input materials; reliability of present supply channels; relationship with suppliers; effect of exchange rate fluctuations on company etc.
3. ***Human Resources***: Skills requirements by the company / industry; attitude of company towards skills development / training; cost of labour and labour market flexibility; employee turnover; ability to replace employees; change in employment levels in recent years and reasons thereof; division of duties (incl. management) etc.
4. ***Technology and Formal Certification***: Maintenance vs. expansion of technology; constraints to technological expansion and investments; technological status quo vis. a vis. requirements of company and industry; formal certification (quality and environmental);
5. ***Present Financial Performance**:* Turnover (growth); financial gearing / debt situation; profitability; exposure to interest rates; access to further capital; sources of capital / restrictions / flexibility; financial constraints to expansion of firm; cash flow situation, etc.
6. ***Future outlook of firm:*** Strategy and vision of management; positive 'feeling' about / from management; likely future market share of firm / change from status quo; ability of firm to diversify into new markets / offer additional services; future capacity to invest in technology; intensity of future competition; ability of firm to adapt to a changing business environment; expected environmental pressure and ability to adapt, etc.

The actual economic / financial analysis was conducted by following a number of pre-determined steps, not only for reasons of consistency, but also to gather the necessary information (as far as being available) as efficiently as possible. First a questionnaire was prepared which was used as a basis for the interviews in the company, although the interviews were not limited exclusively to pre-set questions. Rather, as with the management interview methodology (see chapter 5.2), informal discussions were held to complement the 'formal' questionnaire work. All information was obtained from the companies' Managing Directors and / or owners.

Before the actual interview a background on the company was obtained using information that was already available within the project. Based on this information, an overview of quantitative information was made, to be presented to management for confirmation or amendment. Where not all information was available at the time of the interview, subsequent company visits were arranged to enable management to provide the missing information.

Once all the necessary information was gathered, an overview was created and the companies rated according to the criteria listed above. The six main categories were each assigned a score, after which a final score was derived for each of the companies. This score rates the overall economic strength and current financial performance of the companies, and provides an indication of their ability to obtain finance for further capital expansion and investments.

One of the companies was not willing to discuss any form of economic information with the project-members. Therefore an economic evaluation was not possible.

6.2 The Results of the Economic Evaluation: Companies Economic Health Scores

In Table 6-1 the scores for the companies' economic health are given, based on the results of the interviews.

Table 6-1: Economic situation of the participating companies

Company / Sector	Market Conditions	Supply Conditions	Human Resources	Technology and Certification	Financial Situation at Present	Future Outlook of Firm	Rating of firm
Metal Finishing							Overall Economic Strength, Financial Position, and Ability to Raise Capital
M1	o/-	o	o/-	o	o/-	o	0/-
M2	o	o/-	o/+	o/+	o/+	o	0/+
M3	+	o/+	o/+	o/+	+	+	+
M4	+	o/+	o/+	o/+	+	o/+	0/+
M5	o/-	o/-	o	o	-	o/-	-
Textiles							
T1	o	o/+	o	o/+	o	o	0
T2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
T3	o/+	o	o	o	o/+	o/+	0/+
T4	+	o/+	o	o/+	o/+	o/+	0/+
T5	o	o/+	o/+	o/+	o/-	o/+	0/+

Legend to the overall rating of the firm:
- = Weak economic environment, severe financial distress
0/- = Difficult economic environment, some financial distress
0 = Challenging economic environment, adequate financial performance
0/+ = Positive economic environment, good financial performance
+ = very positive economic environment, strong financial performance

It is noted that most of the companies are in a positive or very positive economic environment, and have good or strong financial performances. Only three companies were in more difficult economic conditions. From this small sample of companies, no conclusions can be drawn as to the general state of the specific industry sectors.

The table shows that within this sample of companies, the market conditions of the different metal finishing companies vary strongly. The two in line companies and the galvaniser are operating in positive market conditions, whereas the job shops are operating in a much more difficult situation. The table also shows that the average supply conditions in the metal finishing industry seem worse than in the textiles industry.

6.3 The Relationship between Economic Health and Potential to Improve Environmental Performance

There were three companies in a less than positive economic situation (overall score lower than 0/+). There was also one company with a very positive economic environment and a very strong environmental performance (score +). Figure 6-1 shows the type of identified improvement options in these 4 companies.

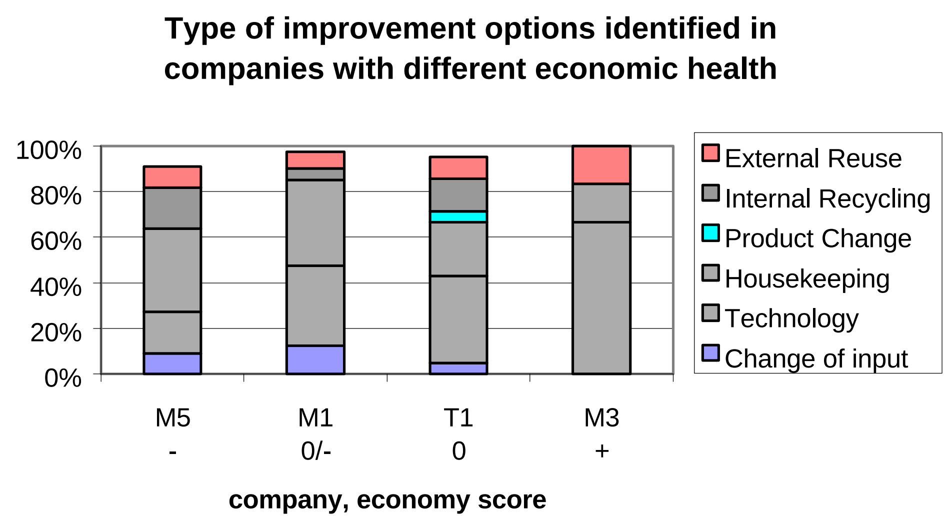

Figure 6-1: Type of improvement options for 4 selected companies

From Figure 6-1 it can be seen that in the company with the best economic health, the options are mostly of the Technology Change type. However, in the company with the worst economic health, most of the options involve Good Housekeeping measures. Figure 6.2 shows this more clearly.

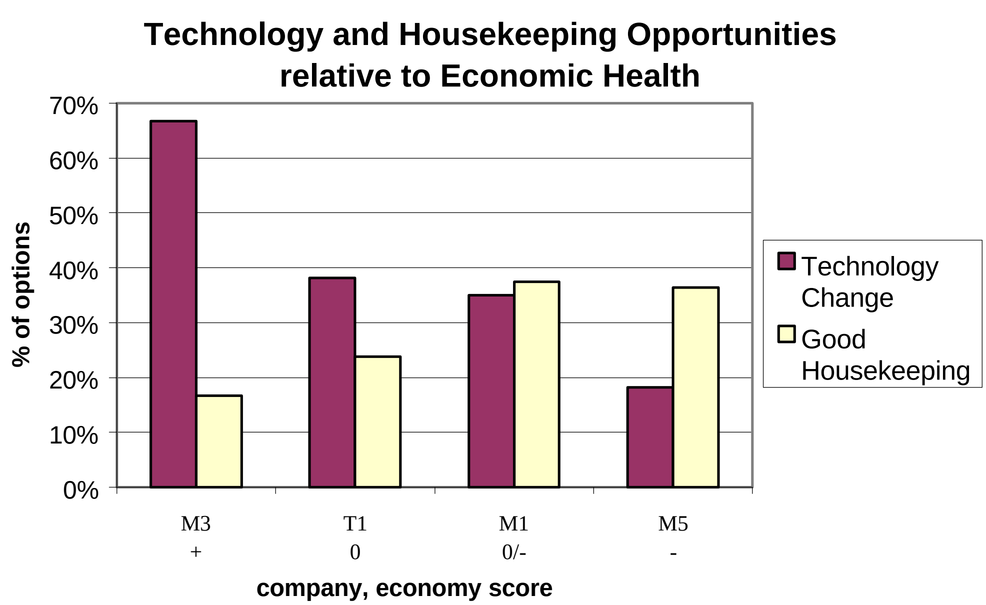

Figure 6-2: Technology and housekeeping improvement opportunities

6.4 Conclusion

It is often said that only economically healthy companies can afford to invest in environmental improvement. We have seen in paragraph 6.2 that three of the participating companies can be categorised as operating in a less than positive economic environment, and being in less than good financial position. This means also that their ability to raise capital is severely affected negatively.

In the case of improvement options that require a large change of technology, larger investment sums can be required. In general there are three sources of capital for a company that needs to invest:
1) Loan finance from a bank or other financial institution
2) Equity from current owners or investors
3) Company reserves (if existing and if enough)

Any company that can easily draw from its own capital will not be categorised as in a weak economic situation, and will not have problems deciding to invest in economically viable improvement options. Companies that need to raise money from banks or other financial institutions for environmental technology will require from the financial institution a certain knowledge and understanding of their specific situation. SMEs often complain that the financial institutions have a) no understanding of the needs of an SME, or b) no understanding of the specific situation of that industry sector. A Cape-based galvanising company, for example, mentioned that the financial institution providing the company with a loan had “little or no knowledge about the metal-finishing industry”.

In this project we found that in those companies that operate in a weak economic environment and are in financial stress opportunities for improvement could still be identified, even though a bias was found towards good housekeeping options that in general need less investments.

As can also be seen in Table 5-5, the companies in the worst economic situation (M1 and M5) also have no capacity to commit human and financial resources, even though they would be willing to do so. This raises the question how these companies can still improve their environmental performance.

Firstly this can be done by improvement measures that need only very little resources: simple good housekeeping measures. To identify and implement improvement measures that require more effort, these companies require assistance. This assistance could be given by different network partners in different ways. It is however important that the support continuous on a longer term, and is not of the ‘once off’ type. This means that one should look towards more structural co-operation and support mechanisms. Those mechanisms will be discussed in the following chapter.

7 Network Analysis: Improvement beyond the Company Boundary

7.1 Introduction

The original project objectives, as discussed in the introductory chapter, envisaged the development of a flow-based, industrial ecology type model of SME manufacturing, which could form a basis for attempts to systematically optimise environmental and economic performance of larger production networks. In chapter 4, it was shown that numerous improvement opportunities extending beyond the capability of individual companies could indeed be found in the case-study companies. The existence of this type of sub-optimal performance (in an eco-efficiency sense) seems to indicate that optimisation of larger systems is a real possibility. Nevertheless, by drawing on experiences from process systems engineering, such an approach would stipulate: (i) that the larger production system can be clearly demarcated; (ii) that functions describing global and local optima can be defined; (iii) that sufficient reliable data exists on flows in the system, and that cause-effect responses to interventions can be introduced mathematically; and (iv) that the system to be optimised is already well controlled at subsystem level, and further amenable to control at system level (since optimisation must always build on control).

In the project, three conditions were identified that disqualify any attempt to optimise at a larger system level. The first pertained to the observation that lacking control at the company level is a frequent cause of sub-optimal performance. This is witnessed by the significant portion of improvement options of the “housekeeping” type, which is symptomatic of control deficiencies. The second condition pertained to the stipulation that it must be possible to clearly demarcate the boundaries of the larger production system. Whilst some of the case-study companies could clearly be assigned to a certain production system (such as a defined component of a motor vehicle, or a building, or a defined type of clothing) others served less well-defined or multiple production systems. In general, we found that it was more useful to view companies as part of networks, than of systems. Third, the condition that sufficient information must be available on flows in all parts of the production system, was found to be unrealisable in the context of the study: this, essentially would have required choosing all case-study companies in a sector from one production system, so as to quantify flows and cause-effect relationships in various sub-systems of the main system, not only in one.

We acknowledge that the second and third conditions discussed here may have arisen as a result of lack of free choice in the selection of case-study companies.

Given thus, that the construction of a quantitative model of SME manufacturing in South Africa was neither feasible in the context of the construction of the study, nor sensible vis-à-vis the current status of environmental performance in the industries considered, we turned our attention to a set of questions arising from the observation that the realisation of numerous identified improvement options required some sort of co-operation between the company and outside organisations. Since our interest still lay in the optimisation of eco-efficiency in manufacturing networks, selecting this focus essentially presumed that the problem can be optimally solved from sub-system level upwards. This is an assumption without basis that needs to be investigated further. Our research was then structured so as to develop systematic methods for the identification of improvement opportunities beyond the company boundary, as well as of partners required to implement such options, and then studied the classification of co-operative mechanisms.

In this chapter we present the methods that we have developed to this end. We also present our findings concerning the prevalence or otherwise of distinctive types of co-operative mechanisms. We define company networks and investigate whether distinctive types of symbiotic behaviour are related to particular positions in the networks of the case study companies.

7.1.1 Industrial networks and network partners

All companies can be said to operate within a network of entities, which generally include categories such as suppliers, clients, financial institutions, waste treatment organisations, knowledge providing organisations, government, etc. This kind of network can be seen as an inter-active system in which sub-systems exchange materials, finance and information.

An industrial network can be defined as a web of organisations connected, directly or indirectly, by material, financial and/or information flows with different magnitudes (see Beers, 2000, for a review of relevant literature). At the outset of this project, a model was developed of interactions between network partners around a textile or metal finishing company. Figure 7-1 shows the model network.

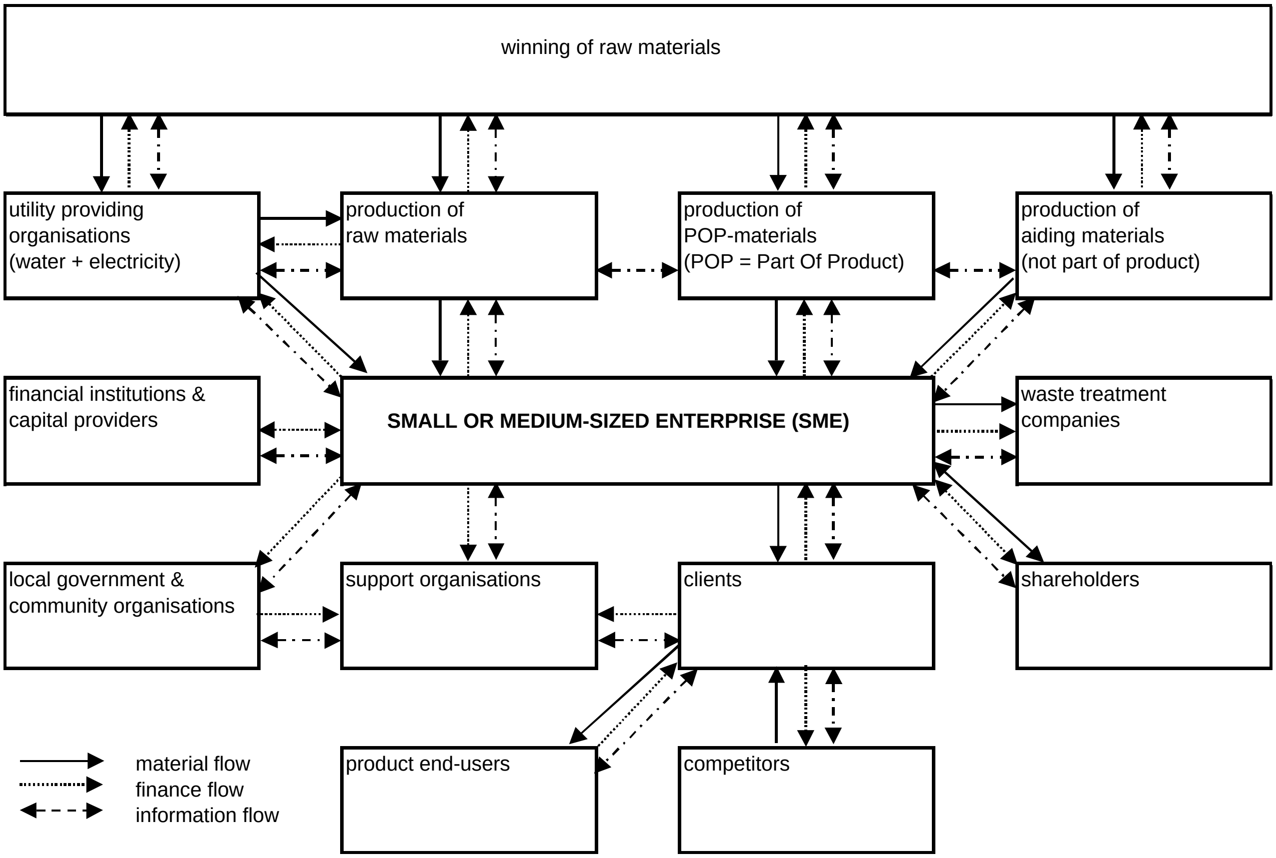

Figure 7-1: Example of an industrial model network with three types of flows

The industrial networks in this project were mapped around specific companies, and can also be seen as a web with the specific focus-company in the centre. This means that each mapped industrial network is unique in terms of structure and relationships between network partners. The methodology developed to develop such network maps is described below, see also Beers et al. (1999) and Beers (2000).

7.2 Description of the Developed Network Analysis Methodology

The mapping of the industrial network is based on the model shown in Figure 7-1. The material, financial and information exchanges between the company and its partners are visualised in network maps by different types of arrows. Table 4-3 in a previous chapter showed the different categories of network partners which can be distinguished. The same categories are used during the network mapping. The focus company can always be seen in the centre of its own network.

The network mapping started after completion of the pre-assessment phase of the waste minimisation assessment (paragraph 4.2.1). The information about the main flows of raw materials, products and waste streams in and out of the company that resulted from the pre-assessment phase, was used as to identify the main network partners.

Worksheets have been developed for each category of network partners. These worksheets were used to record the nature and intensity of exchanges in the network as efficiently and systematically as possible, and to assist in establishing what additional data needed to be gathered after the pre-assessment phase. During interviews with company staff, the worksheets were used as guidelines for the interviews. Examples of the worksheets are included in Appendix 7.

Additionally to the interviews of company staff, network partners were approached for further information on quantity, quality, origins or fate of materials, and on the nature of the relationship with the company. The completed worksheets contain all the relevant information to map the industrial network around the company.

The information obtained was expressed in units of intensity of the flows. The intensity of material and financial flows was always related to the case-study company in the research project (the centre of the network). The information flows always visualise the exchange of information between two organisations in the network and its intensity is not related to the company in the centre of the network. Because the size of the case-study companies varied from 25 employees to 500 employees, different intensity criteria have been formulated for smaller and bigger companies. In Table 7-1 and Table 7-2 the intensity criteria are given.

Table 7-1: Intensity criteria for companies smaller than 200 employees

Flow intensity	**Material flow** [kg/litre/products per year]	**Financial flow** [Rand per year]	**Information flow** [personal contact]
Very high	> 100,000	> 1,000,000	Daily
High	10,000 to 100,000	100,000 to 1,000,000	Weekly
Medium	1,000 to 10,000	10,000 to 100,000	Monthly
Low	0 to 1,000	0 to 10,000	Yearly

Table 7-2: Intensity criteria for companies larger than 200 employees

Flow intensity	**Material flow** [kg/litre/products per year]	**Financial flow** [Rand per year]	**Information flow** [personal contact]
Very high	> 1,000,000	> 10,000,000	Daily
High	100,000 to 1,000,000	1,000,000 to 10,000,000	Weekly
Medium	10,000 to 100,000	100,000 to 1,000,000	Monthly
Low	0 to 10,000	0 to 100,000	Yearly

The material flows were measured in flows of products, raw materials or wastes, expressed in units of mass, or volume, or sometimes in number of products. The flows of money were always expressed in terms of Rand per year. The information flow was categorised by the frequency of the personal contacts between the network partners. This personal contact could be by phone or in nature. A general leaflet from a network organisation informing about a product or service is not seen as personal contact, even when addressed to a specific person.

7.3 The Network Maps: Exchanges of Material, Money and Information

7.3.1 Detailed company networks

The industrial network information from the network mapping was visualised with computer software (Micrografx Flowcharter) and was plotted in colour on A1 size paper. The different flows (material, financial and information) are indicated with arrows of different colours on the map. The thickness of the arrow is a measure of the intensity of the flow. Figure 7.2 gives an indication of such an illustrated industrial network map for a textile printing SME in South Africa.

We tried to summarise the information from the worksheets and detailed network maps of the 10 individual companies in two general network models of the two industry sectors (textile industry and metal finishing industry). Although this would lead to a loss of information detail, it was postulated at the same time that these would provide us a better overview of the type of network links and flows in the two industry sectors.

The position of a client in the network is always relative to the position of the central company. Therefore we have identified three levels of clients. Level 1 clients are direct clients of the company. Level 2 clients are the clients of level 1 clients. Level 3 clients then are the clients of those at level 2. It is not necessarily so that level 3 clients are always the end-users or that level 1 clients are always other manufacturing companies. Table 7-3 gives some examples of level 1, 2, and 3 clients of some of the companies that participated in the project.

Table 7-3: Examples of level 1, 2 and 3 clients

Company	Maintenance hard-chroming of machine parts	Textile commission printing	Design and manufacturing of clothing
Level 1 clients	Manufacturing companies	Designers and manufacturers of clothing	Retailers
Level 2 clients	-	Retailers	End users
Level 3 clients	-	End users	-

7.3.2 Material, finance and information exchanges in the metal finishing industry

An overview of the main exchanges of material, information and finance between the main network partner categories in the metal finishing industry is given in Table 7-4 and discussed below.

Table 7-4: Intensities of network flows for metal finishing companies

Flow:	**Flow direction**		**M4**	**M3**	**M5**	**M1**	**M2**	**Model**
1	**Suppliers**	**Company**	**FLOW INTENSITY (*0)**					
Material	→		VH	VH	H	VH	VH	VH
Finance	←		VH	VH	H	VH	VH	VH
Information	←→		H	H	H	H	M	H
2	**Company**	**Clients level 1**						
Material	←→(*1)		VH	VH	M	VH	VH	VH
Finance	←		VH	VH	VH	VH	H	VH
Information	←→		H	VH	H	VH	VH	VH
3	**Clients level 1**	**Clients level 2**						
Material	→		VH	VH	-	VH	H	VH
Finance	←		VH	VH	-	VH	?	VH
Information	←→		H	H	-	H	?	H
4	**Clients level 2**	**Clients level 3**						
Material	→		VH	VH	-	VH	-	VH
Finance	←		VH	VH	-	VH	-	VH
Information	←→		H	H	-	H	-	H
5	**Competitors**	**Clients level 1**						
Material	←→ (*2)		-	M	?	VH	M	M
Finance	←		-	H	?	VH	M	M
Information	←→		-	M	?	H	M	M
6	**Competitors**	**Clients level 2**						
Material	→ (*3)		VH	M	-	-	?	?
Finance	←		VH	M	-	-	?	?
Information	←→		H	L	-	-	?	?
7	**Competitors**	**Company**						
Material	←→		-	-	L	-	M	L
Finance	→		-	-	M	-	L	L
Information	←→		-	-	M	-	VH	L

8	**Company**	**Waste companies**						
Material	→		VH	VH	VH	VH	VH	VH
Finance	←→ (*4)		M	M	M	M	L	M
Information	←→		M	H	M	L	M	M
9	**Government**	**Waste service** (*5)						
Material	-		-	-	-	-	-	-
Finance	→		M	M	M	M	M	M
Information	←→		H	H	H	H	H	H
10	**Company**	**Support organisations**						
Material	-		-	-	-	-	-	-
Finance	→		M	M	M	M	L	M
Information	←→		H	H	M	M	H	H
11	**Government**	**Company**						
Material	→		VH	VH	VH	VH	VH	VH
Finance	←→(*6)		H	H	M	M	H	H
Information	←→		M	M	L	M	L	M
12	**Company**	**Shareholder**						
Material	-		-	-	-	-	-	-
Finance	←→		VH	VH	H	H	H	H
Information	←→		H	H	VH	VH	M	H
13	**Suppliers**	**Government**						
Material	→		VH	VH	VH	VH	VH	VH
Finance	←		M	M	M	M	H	M
Information	←→		?	?	M	M	M	M

(*0): flow intensity abbreviations: VH = very high, H = high, M = medium, L = low. See Table 7-1 and Table 7-2 for intensity criteria
(*1): material flow one way for M3 and M4
(*2): material flow one way for M3 and M4
(*3): material flow bidirectional for M5
(*4): finance flow one way from company to waste company for M5
(*5): relates only to flow of money to local municipal waste water treatment plants
(*6): finance flow one way from company to government for M5 and M1
(*7):Uncertain whether these companies are representative in this field. Most SMEs don't use government finance funds and/or are unfamiliar with them

<u>1: Exchanges between suppliers and the companies</u>
The flows between the company and its suppliers were characterised by a very high exchange of material and finance, and a high exchange of information. The material flows were mostly unidirectional to the company. Only the galvanising company returned wastes (zinc-ash and -dross) to the supplier for reprocessing.

<u>2: Exchanges between clients and the companies</u>
The finance flows between the companies and their direct clients were always very high. The information exchanges varied from weekly (high) to daily (very high). The material flows were unidirectional to the clients in the case of the two in-line electroplating companies, but the flows were bi-directional in the case of the job-shops. This is logical since the job-shops receive their material from their clients.

<u>3 and 4: Exchanges in the market, between the different client levels of the companies</u>
The flows of material and finance between clients and their respective clients were always very high, and the information exchange took place on a weekly basis. The structure of the market for their products or services differed strongly and clients on level 2 and/or 3 were not always present, as well as the interactions between different client levels. In some cases the competition was mainly for the clients on level 2 (retail outlets) and in other cases for the clients on level 1 (distributors).

5 and 6: Exchanges between the competitors and the clients of the companies

The material, financial and information exchanges between the competitors of the companies and the different client levels varies strongly. This means that the companies in the project are each in a different market and competitive situation. One can say that the bigger companies in the automotive component industry (M3 and M4) do experience competition for their level 2 clients, whereas smaller job-shop metal finishers do not have links to such distant customers.

7: Exchanges between the companies and their competitors

Direct relationships with competitors mostly don't exist. Only in the case of two of the three job-shops are there low to medium intensity exchanges with competitors.

8: Exchanges between the companies and the waste management and treatment companies

The material flows from the company to the waste companies were always very high for the waste water, and high for the other wastes. Since most of the companies recycled scrap metals, there were financial flows in both directions. The information exchanges varied from high to low. In the case of the collection of municipal waste by the municipality, the information exchange was mostly categorised by the companies as absent.

9: Exchanges between the waste management and treatment companies and the government

The financial flows from the local government to the municipal waste water treatment plants was categorised as medium, whereas there was an almost daily exchange of information.

10: Exchanges between the companies and their support organisations

The financial exchanges with support organisations were mostly categorised as of medium intensity. There were no material exchanges between the companies and the support organisations. Mainly information was exchanged. The main support organisations with whom the companies had more than medium intensity information exchange were unions, employer and industry organisations, and research organisations. The last network partner (research organisations) is obvious since the companies were at the moment of the research involved with the University of Cape Town in this research project.

11: Exchanges between the companies and the governmental organisations

The material flows between the companies and the government was always very high. This relates to the large flows of water and/or electricity which are mostly provided by the local government. The financial and information flows between government and the companies must be distinguished into exchanges with local government, and exchanges with national government. For the larger companies, the flow of money from national government support programs into the companies was larger than the flow of money out of the company to the local government (mainly for water, electricity and waste services). The smaller companies were not part of government support programs and only had a net money flow out of the company to the government.

Tax flows to national government were low for M1 and M5, medium for M2 and M4, and high for M3, which translates to a medium average.

The information flows between the companies and the government differed. The contacts with local government were confined to quarterly water and electricity bills. The contacts with national government about financial support were often more frequent.

12: Exchanges between the companies and their shareholders

The relations with shareholders show a distinction between the smaller job-shops and the larger in-line metal finishing companies. Obviously, there were no material exchanges between the companies and their shareholders. The larger in line companies had a very high finance flow and a high information exchange whereas the smaller job shops showed a high finance flow and a very high information exchange.

13: Exchanges between the suppliers and the government

The relationship between suppliers and government as presented in the above table was solely based upon the supply of electricity to local government by Eskom. The relationships between government and individual suppliers of equipment and raw materials was not investigated in this network mapping. However, during the three years of the project other interactions with suppliers and governmental organisations took place. Based on these experiences it can be said that there is very little exchange of information between suppliers to the metal finishing industry and governmental organisations about environment-related aspects of the suppliers' products.

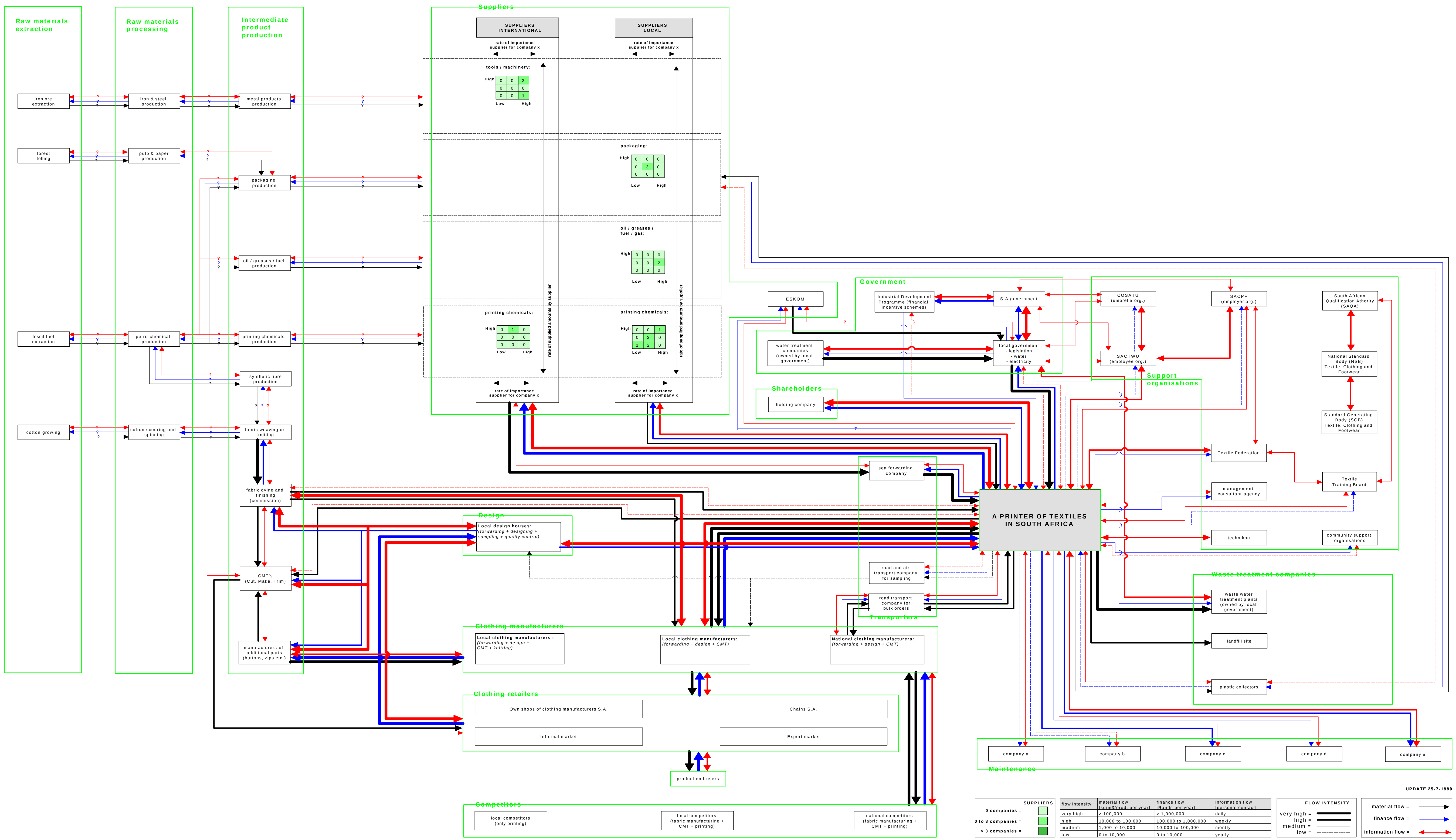

Figure 7-2: Example of an industrial network map of a company

7.3.3 A general network of the metal finishing industry

Based on the information from Table 7-4, a summarised model picture was drawn, with the average flows and intensities as can be found in the 'model' column in Table 7-4. The resulting summarised network is given in Figure 7-3.

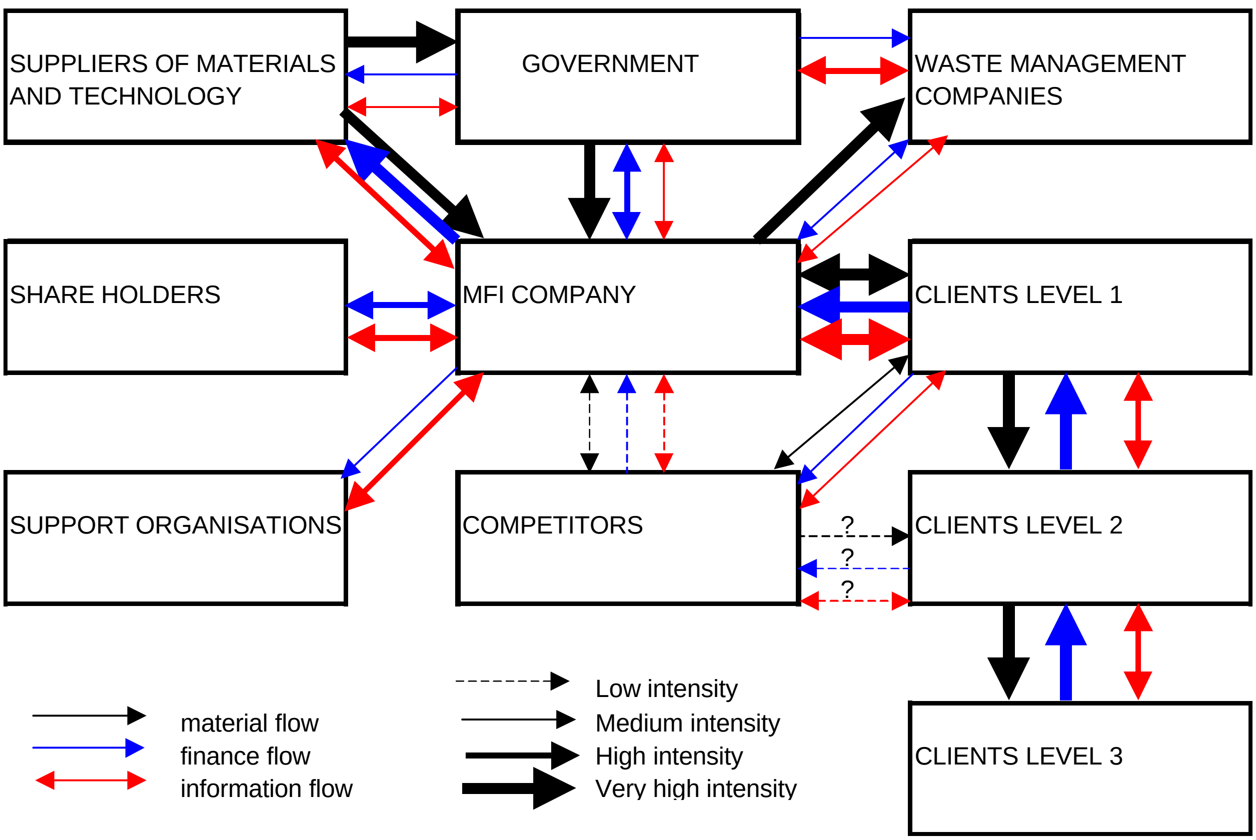

Figure 7-3: general summarised network of the metal finishing industry

7.3.4 Material, finance and information exchanges in the Textile Industry

An overview of the main exchanges of material, information and finance between the main network partner categories for 4 of the participating companies in the textiles industry is given in Table 7-4 and discussed below.

Table 7-5: Intensities of network flows for textile companies

Flow:	**Flow direction**		**T3**	**T5**	**T2**	**T1**	**Model**
1	**Suppliers**	**Company**	**FLOW INTENSITY (*0)**				
Material	→ (*1)		VH	VH	VH	VH	VH
Finance	←		VH	VH	VH	VH	VH
Information	←→		VH	H	M	H	H
2	**Company**	**Clients level 1**					
Material	→ (*3)		VH	VH	VH	VH	VH
Finance	←		VH	VH	VH	VH	VH
Information	←→		VH	H	VH	VH	VH

3	**Clients level 1**	**Clients level 2**					
Material	→		VH	VH	VH	VH	VH
Finance	←		VH	VH	VH	VH	VH
Information	←→		H	H	VH	H	H
4	**Clients level 2**	**Clients level 3**					
Material	→		-	-	VH	VH	VH
Finance	←		-	-	VH	VH	VH
Information	←→		-	-	H	H	H
5	**Competitors**	**Clients level 1**					
Material	→ (*4)		VH	VH	VH	VH	VH
Finance	←		VH	VH	VH	VH	VH
Information	←→		VH	H	VH	H	VH
6	**Competitors**	**Clients level 2**					
Material	→		-	-	-	-	-
Finance	←		-	-	-	-	-
Information	←→		-	-	-	-	-
7	**Competitors**	**Company**					
Material	←→		-	-	-	-	-
Finance	→		-	-	-	-	-
Information	←→		-	-	-	-	-
8	**Company**	**Waste companies**					
Material	→		VH	VH	VH	VH	VH
Finance	→ (*2)		L	M	L	L	L
Information	←→		L	M	L	L	L
9	**Government**	**Waste companies**					
Material	-		-	-	-	-	-
Finance	→		M	M	M	M	M
Information	←→		H	H	H	H	H
10	**Company**	**Support organisations**					
Material	-		-	-	-	-	-
Finance	→		M	M	H	M	M
Information	←→		M	H	M	M	M
11	**Government**	**Company**					
Material	→		VH	VH	VH	VH	VH
Finance	← (*5)		M	?	H	H	H
Information	←→		L	M?	M	M	M
12	**Company**	**Shareholder**					
Material	-		-	-	-	-	-
Finance	←→		?	VH	H	VH	VH
Information	←→		?	VH	VH	H	VH
13	**Suppliers**	**Government**					
Material	→		VH	VH	VH	H	VH
Finance	←		M	H	H	M	M
Information	←→		?	?	?	?	?

(*1) Material flow bidirectional for T3
(*2) Finance flow bidirectional for T5
(*3) Material flow bidirectional for T2 and T1
(*4) Material flow bidirectional for T2 and T1
(*5) Finance flow bidirectional for T1, and uncertainty as to existence of subsidy for T5.

1: Exchanges between suppliers and the companies

The flows between the typical company and its suppliers were characterised by a high exchange of information and finance. The material flows were mostly unidirectional from the supplier to the company. The material flows were only bi-directional in the case of the dyeing and CMT company (T3). A commission printers provides a service for them by printing onto fabric supplied by T3. The printer then returns this fabric.

2: Exchanges between clients and the companies

The material and finance flows between the companies and their direct clients were always very high. The information exchanges mostly were on a daily basis (very high), and in one case on a weekly basis (high). The material flows were unidirectional from the company to the clients, except in the case of the two commission printers (T1 and T2) that print on textile from their clients. In those cases the material flow is bi-directional.

3 and 4: Exchanges in the market, between the different client levels of the companies

The flows of material and finance between clients and their respective clients were always very high, and the information exchange mostly took place on a weekly basis. The structure of the market for their products or services differed strongly and clients on 3 were not always present, as well as the interactions between different client levels. In the case of companies producing complete consumption goods that can be sold directly to the consumer, level 1 consisted of the retail and wholesale outlets, level 2 were the consumers, and there was no level 3. In the case of the commission printers, level 1 were the textile manufacturers, level 2 the retailers (often chains), and level 3 were the consumers

5 and 6: Exchanges between the competitors and the clients of the companies

The material, financial and information exchanges between the competitors of the companies and the clients on level 1 is mostly very high. Contacts between competitors and level 2 clients (retail or consumers) were never reported.

7: Exchanges between the companies and their competitors

Direct relationships between the companies and their competitors did not exist in the textiles industry companies.

8: Exchanges between the companies and the waste management and treatment companies

The material flows from the company to the waste companies were always very high for the waste water, and high to very high for the other wastes. The information exchanges were mostly low (annually) and in one case medium (monthly). In the case of the collection of municipal waste by the municipality, the information exchange was mostly categorised by the companies as absent.

9: Exchanges between the waste management and treatment companies and the government

The financial flows from the local government to the municipal waste water treatment plants was categorised as medium, whereas there was a high (daily) exchange of information.

10: Exchanges between the companies and their support organisations

The financial exchanges with support organisations were mostly categorised as of medium intensity. There were no material exchanges between the companies and the support organisations. Mainly information was exchanged, mostly on a weekly and in one case on a daily basis. Only two companies had more than medium intensity information exchange with support organisations. These exchanges were with unions and research organisations.

11: Exchanges between the companies and the governmental organisations

The material flows between the companies and the government was always very high. This relates to the large flows of water and/or electricity which are mostly provided by the local government. The financial and information flows between government and the companies must be distinguished into exchanges with local government, and exchanges with national government. All companies paid money to local government, and only one company was part or had been part of a government support programme and had a money flow from the government to the company.

Tax flows were low for T1 and T5, medium for T3 and high for T4, which translates to a medium average for the companies studied.

The information flows between the companies and the government differed. The contacts with local government were confined to quarterly water and electricity bills. The contacts with national government about financial support were often more frequent.

<u>12: Exchanges between the companies and their shareholders</u>
Obviously, there were no material exchanges between the companies and their shareholders. All companies had high or very high exchanges of finance and information with their shareholders. One company was not prepared to give any information about contacts with shareholders.

<u>13: Exchanges between the suppliers and the government</u>
The relationship between suppliers and government in this analysis was solely based upon the supply of electricity to local government by Eskom. The relationships between government and individual suppliers of equipment and raw materials was not investigated during this network mapping endeavour.

7.3.5 A general network map of the textile industry

Based on the information from Table 7-5, a summarised model picture was drawn, with the average flows and intensities as can be found in the 'model' column in Table 7-5. The resulting summarised network is shown in Figure 7-4.

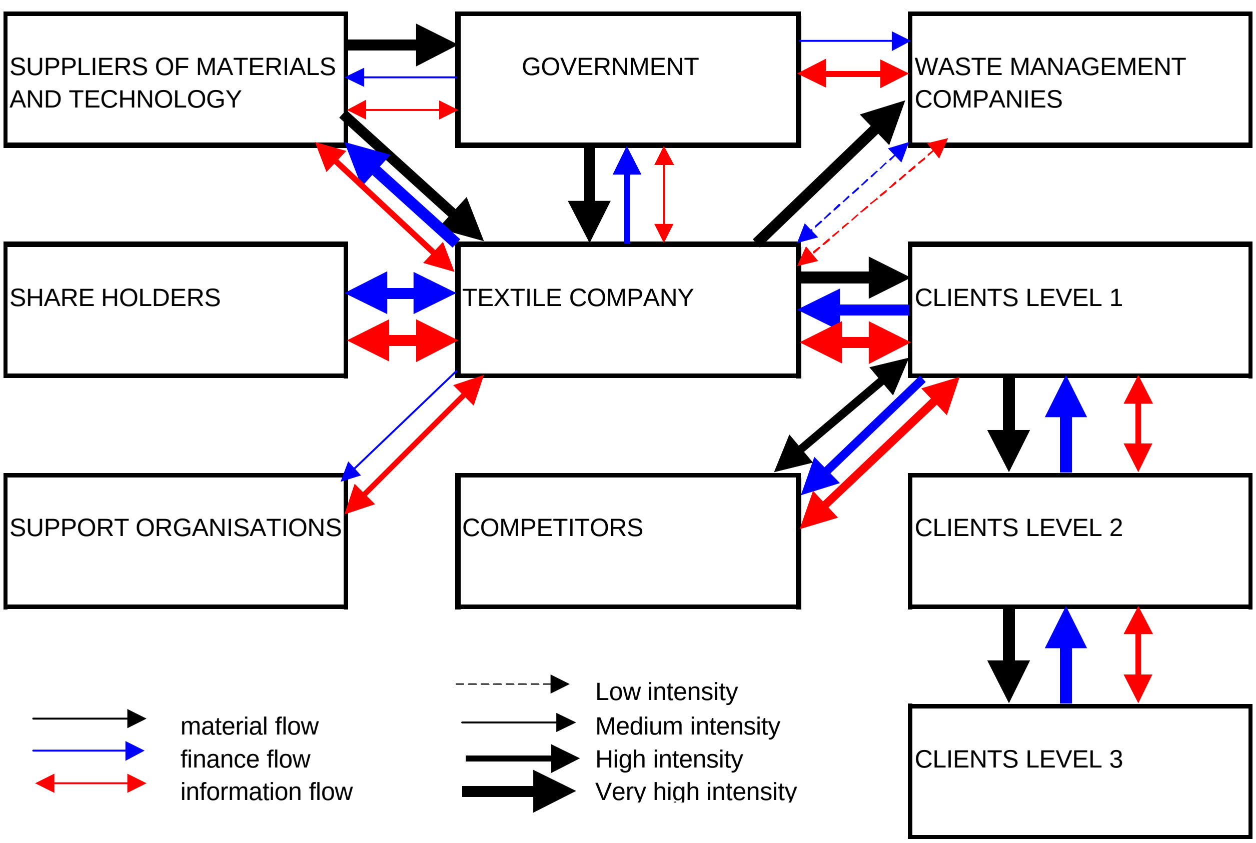

Figure 7-4: General summarised network of the textiles industry

7.3.6 Comparison of the general networks

In comparing the network maps of the two industry sectors, it should be borne in mind that the five metal finishing companies studied serve three different market sectors (automotive, construction and machining), and in three cases are wider operations incorporating a finishing section (as defined per Figure 3-1), whereas the four textile companies upon which their general network is based incorporate the full range of the textile manufacturing operations shown in Figure 2-1 (from scouring through spinning, weaving and knitting to finishing (printing, dying) and CMT).

If we compare the two general networks of the textiles industry (Figure 7-4) and from the metal finishing industry (Figure 7-3), then we see that there are more similarities than differences. The main differences are:

- there was less contact between competitors and the textile companies then there was between competitors and the metal finishing companies. This seems to point to a more competitive environment in the textile industry. Interestingly, however, it is two of the metal finishing companies that report an overly competitive market (see Table 6-1).
- The relative amount of money lost on wastes and emissions, and the contacts with waste companies was much lower in the textile companies than in the metal finishing companies.
- The involvement of shareholders in the companies is larger in the textile companies than in the metal finishing companies.

7.4 Systematic Identification of Improvement Opportunities in Networks

Having developed a method to gather information on company and industry networks, and for their graphical depiction, a specialised study was then launched within the project to determine whether such an understanding of networks can be used as a basis to systematically identify improvement options external to the focus company. The motivation here was that all improvement options are normally identified through the application of waste minimisation techniques, which are specifically focused on flows within manufacturing operations, and not between them.

An extensive report of this study may be found in v. Beers (2000), who proposes and describes a new tool, the Industrial Network Analysis (INA) for this purpose. Central to the methodology are two techniques to identify potential network improvements:

(i) A network brainstorming session which is done with company staff of the SME. An industrial ecology checklist is used as a guideline during the discussion. This checklist is an abridged version of the checklists set up by Graedel & Allenby [1995] and DeSimone & Popoff [1997].

(ii) A network impact matrix, which is based on the matrix LCA as described by Graedel [1998]. The aim of the network impact matrix is the identification of environmental constraints within the industrial network. Once the network constraints have been identified, possible ways to eliminate these constraints can be sought through a pro-active partnership approach.

The developed industrial approach was tested on two of the case study companies, viz. a textile printing company (T1) and aluminium powder coating company (M1). Whilst identifying a range of options, both internal and external to the companies, v. Beers (2000) found that only a few of the external options had not previously been identified by the Waste Minimisation Assessment. He thus concludes from his study that the most efficient way to identify such external improvement options in SMEs is to modify the classical Waste Minimisation Assessment to include some of his techniques, and indeed the network mapping procedure described above.

7.5 The place of Improvement Options in the Networks

In chapter 4 the results of the waste minimisation assessments in the case study companies were presented, and an analysis showed that a large proportion of the identified improvement options either necessitated assistance from an outside organisation, or would benefit from co-operation of the company with an outside organisation. Having defined networks around manufacturing SMEs, and having shown the typical structure of such networks for the metal finishing and textile sectors, the next step in our investigation was to relate the identified improvement options to the position of the companies in their networks. In the following paragraphs, we will first discuss the role of different network partners in implementing the five prevention techniques, and then look at how partnerships can be formed for the implementation of specific improvement options.

7.5.1 Co-operation and the prevention techniques

As discussed in section 4.3.1, most of the identified options involve good housekeeping or technology changes followed by internal recycling, changes in raw materials, and external recycling. We have also seen from Table 4-4 that suppliers are the main network partners for implementation of the improvement options, followed by support organisations. In the following paragraphs we discuss the roles of different network partners in the implementation of improvement options as they relate to the five prevention techniques.

Good housekeeping options are mostly relatively simple options that can easily be implemented by the company without outside help. Only in the case of good housekeeping options that involve changes in management systems, outside expertise is sometimes used by small companies. For example the design and implementation of a proper chemicals registration and consumption monitoring system can take too much of the time of the manager of a small company. In that case, expertise from outside can help to speed up the process. It can prevent the company from spending valuable time reinventing the wheel. Another example is the supportive co-operation that local government can give to efforts of SMEs to reduce water consumption by implementing a water consumption monitoring system. Local government can provide extra information on the monthly water bills, and/or support the initiatives with water consumption awareness posters, providing simple water saving equipment for the homes of the employees etc.

Changes in input materials and *technology changes* mostly need assistance from suppliers of raw materials and/or technology. The problem for SMEs is how to know about the existence of these options, and how to judge them. Although most SMEs do have access to industry-specific journals and magazines, SMEs often mainly depend on their suppliers for judgements of the applicability of these new technologies. This is even more the case when a supplier has built up a relationship over the years, and the manager of the SME has put his or her trust in the supplier. Industry sector organisations can help to break this dependency on the suppliers for technological expertise.

Sometimes changes in input material and/or technology changes need co-operation with clients and certification bodies. This is the case if the change involves a certified process. In that case the co-operation of the supplier, the client and the certification body is needed to get the new process certified again. This observation is based on the following case from our research: A small powder coating company risked loosing the powder suppliers support for its 30 year guarantee on its work, after changing the process by substituting a toxic chemical for a less hazardous chemical. A new certification process was needed and this could not be done without the suppliers help.

Implementation of options that involve *product changes* obviously need contact with clients. Although 5% of the identified improvement options in the participating companies involved product change, only one of these options was actually seriously considered for implementation by a company. In general the attention paid to environmental product development, or eco-design is very low in the South African textile and metal finishing industry. This could be caused by a number of reasons:

1) Firstly the fact that most SMEs in South Africa have only relatively recently learned about preventative environmental management concepts such as Cleaner Production, Cleaner Technology, Waste Minimisation, Life Cycle Assessment, Environmental Management Systems, etc. According to a recent survey amongst 200 SMEs in the Port Elizabeth Metropolitan Area (Jeppesen, 1999) only a few companies apply Cleaner Production Technologies, Waste Management and Environmental Management. Table 7-6 shows the results of the survey. This could be caused by the fact that SMEs are mainly short term thinking

(as also shown in section 5.5), and in South Africa at this moment, implementing advanced environmental concepts such as environmental product development is rather a medium or long term strategic decision.

Table 7-6: The use of cleaner production technologies, waste management systems and environmental management systems among SMEs (Jeppesen, 1999)

Size \ system	Cleaner production technologies		Waste Management		Environmental Management System	
	No.	%	No.	%	No.	%
Micro	9	26%	10	29%	1	3%
Small	39	29%	55	41%	13	10%
Medium	17	63%	22	82%	14	52%
Total:	*67*	*33%*	*89*	*44%*	*30*	*15%*

2) The service providing companies in the product chains of the textiles and metal finishing industry (commission printers, electroplating or galvanising job shops etc.) have very little direct influence in the designing process of the product. They basically ‘only’ perform a service (printing, electroplating, galvanising, etc.) on their clients’ products. The companies that do design a product often do so within strict limits set by their larger corporate clients (retail chains, automotive companies). The automotive component manufacturing company that participated in the project had very little say over the final finish of parts of their product. This was mainly decided by the demands from the large automotive manufacturers. Even though in Europe there seems to be a trend towards environmental product design of cars (design for recycling etc.), the South African automotive component manufacturers do not seem to notice too much of that.
3) The market (and the average consumer) in South Africa does not place much value on environmentally friendly products. Environment as a product sales argument is only very young in Europe and the USA, and in South Africa there are only very few case studies of companies who successfully applied Design for Environment on the South African Market. The textile retail chains that we spoke to all mentioned that environment is not a sales argument in the South African market. There were 5 companies in the project that had direct influence on their product and that had a certain degree of freedom in decision making around the design of their product. None of these companies was the slightest bit interested in environmental product design. All of them gave as reason that the market was not interested in it, so why should they spent energy, time and money on it. These perceptions may however be ignoring recent trends amongst consumers, as claimed in a recently completed research thesis (Cowan, 1999).

Internal recycling options sometimes require a change in the quality or characteristics of the used raw materials or sometimes require a new technology to be installed. These new technologies are mostly separation technologies. In those cases, co-operation with a supplier is necessary.

External recycling options depend on the market for the reusable waste materials. Therefore the main network partner is the buyer of these materials. A second important role can be played by a ‘broker’ of reusable waste streams. Sometimes this function is taken by a governmental organisation, sometimes by a service provider or support organisation.

7.5.2 Generic improvement options and their place in the network

A number of improvement options were identified in several companies. In this section we shall investigate these options further, identifying the partnerships that these options require and how they fit into the networks

Besides the many company- and technology specific options that were identified, there were 6 options that were mentioned in three or more companies. Three of these involve good-housekeeping procedures, two involve internal recycling (with add-on technology) and one involves external recycling. Table 7-7 gives an overview of these options.

The three good-housekeeping options are all three options that continue on the longer term and that can lead to a change in the culture of the company towards a preventative culture. These options can be implemented independently by the company on its own, but mostly require supportive co-operations from network partners.

The government can play a supportive role in the monitoring of water consumption, by providing extra information on the monthly water bills.

Table 7-7 : Overview of recurring options in the participating companies

Option	Number of companies where identified	Prevention technique
Continuous training and awareness of employees	6	Good Housekeeping
Continuous monitoring of water consumption	7	Good Housekeeping
Continuous monitoring of chemicals consumption	4	Good Housekeeping
Re-winning of Chromium from sludge	3	External re-use
External reuse of wastes / waste exchange.	5	External re-use
Treatment and internal re-use of wastewater	4	Internal re-use

The internal reuse of water mostly requires some form of water treatment to ensure that the water is of the right quality so as not to disturb the processes. Therefore the services of a technology supplier are mostly essential.

The external reuse of waste options are different in nature. The re-winning of chrome may require a shared facility, or else a new company that operates the re-winning technology. The waste exchange option requires an outside organisation that co-ordinates and facilitates a structural waste exchange facility. This could be done by a governmental organisation, or by any type of support organisation.

These different options and the required network co-operation are depicted in Figure 7-5 (v. Beers, 2000).

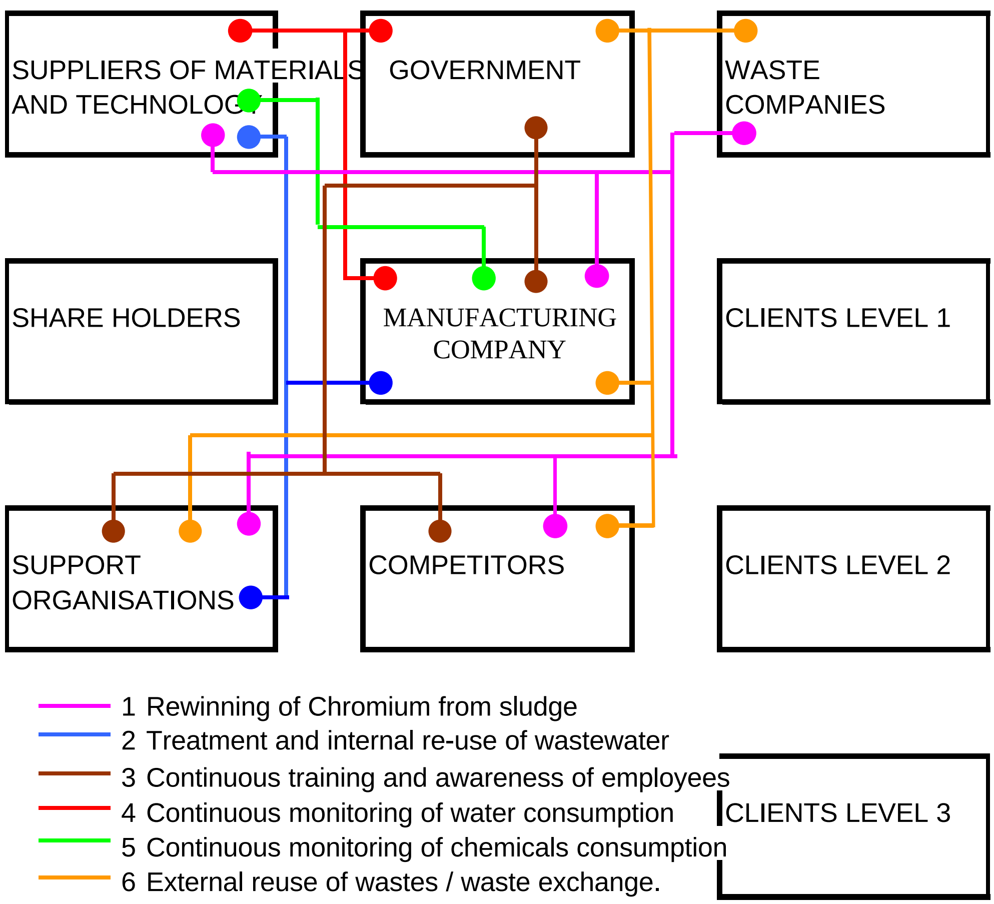

Figure 7-5: Improvement options and their required network co-operation

From Figure 7-5 it can be seen that the suppliers play a role in 5 out of the 6 options, the support organisations in 4 out of the 6 options, and that neither the shareholders nor the clients play a role in the most frequently recurring options.

7.6 Mechanisms for Co-operative Approaches

The identification of improvement options, whether by classical waste minimisation assessments, or by the modified method as proposed by v. Beers (2000), and the selection of appropriate partners to aid in the implementation of such improvements may in some cases be all that is necessary to effect a step change in the performance of a production system. In other cases the structuring of eco-beneficial co-operation may be less intuitive, and may require innovative solutions. It is the purpose of this section to review the theory of co-operation, and to discuss some types of symbiotic relationships proposed in Industrial Ecology literature. The application in and applicability to the South African situation will feature prominently.

7.6.1 General and eco-specific co-operation

There is much literature on co-operative company networks and clusters. Some of it is about purely economic co-operations (supplier-client relationships) (v. Dijk, 1999; Schmitz 1999), some about competitive relationships (Porter, 1980, 1985, 1998) and some about environment-oriented relationships (Porter and van der Linde, 1995).

a) Preconditions to effective co-operation between companies

Problems and issues are best resolved when all those impacted upon are involved in the problem solving process. Collaboration among the relevant sectors of society, e.g., government, business, labour and communities, is thus a necessary precondition to effective problem solving.

Guetzkow (1996) describes one type of interaction among organisations as the *interpenetration* of organisations. Here the discussion is around permeability - the transfer of information, technology, people and machines across organisational boundaries. Another type of interpenetration is ideological. Communication across organisational boundaries results in the transformation of ideas of the target group, i.e., persuasion. This section of the report will focus on the interpenetrational processes that lead to a network of organisations that will potentially be involved in collective problem solving.

Gray (1985) describes collaboration as “the pooling of appreciations and/or tangible resources by two or more stakeholders to solve a set of problems that neither can solve individually”. This requires certain *norms* of reciprocity that must be taken into account, such as, sharing of technical information; subcontracting out to less successful competitors; and refraining from wage competition and labour poaching. Reciprocity also reduces the risk of investing in new production methods and technologies. The risks are reduced when all parties share the costs of innovation and all are in agreement on the limits to competition. Such a relationship of open mutualism is built on trust among organisations and strengthens their ties (Gray, 1985; Lorenz, 1992).

An aspect that features strongly in the literature is *social capital*. Bosworth and Rosenfeld (1995) describe social capital as “the ability of people to work together for some common purpose”. There are various defining characteristics that need to exist before social capital is realised. The group concerned (community) must value co-operation, trust and interdependence; it must adhere to certain norms of reciprocity and organised networks and associations for engagement (previous section). For it is not the economic system that determines the degree of social engagement but the resources that are put into social capital that have the potential to promote economic performance.

Gray (1985) discusses a three-phase process model of collaboration. She notes that although this is a natural sequence of phases, internal or external forces can “interrupt, enhance or impede” the process. The first phase is *problem-setting*. This requires the identification of stakeholders who acknowledge the issue that joins them. Consensus about who has a legitimate stake is reached and clarity is given on what the joint issues is. The interdependence nature of the issue is stressed so that all parties can appreciate and understand it. The second phase is *direction-setting*. Here stakeholders express the values that guide their individual pursuits and relate them to the values underlying the common purpose, which will bring about mutually desirable ends. The third phase is *structuring*. This phase ensures an ongoing sense of appreciation and the effective management of stakeholder interactions, thereby enhancing the process of collaboration. A mutually acceptable regulative framework for co-operation is negotiated.

To provide an example of network penetration using the model, the promotion of industrial symbiosis requires a degree of persuasion or boundary penetration. In order to adjust the goals of companies from being purely profit-driven to being profit-driven within the realm of environmental responsibility (problem-setting), an external force of communication penetrates them. This initial communication then results in various activities (seminars, incentives from local government, etc.) that will further the process of persuasion and that ultimately result in the desired goal of a network of companies co-operating with each other.

Co-operation can only occur insofar as external controls allow it to. The degree to which networks are dependent on external resources from a single source for survival and goal achievement affects whether or not the system is self-regulating. Dependence on resources from several sources reduces dependency on any single customer or client group. Laws and regulations or policy decisions made by the state also affect the degree to which networks are self-regulating. Resource dependency, state regulations as well as characteristics of the economy thus determine the amount of network regulation and can either promote or inhibit self-governance. Too much external control can lead to a loss of interest and a sense of helplessness from network members and a breakdown in the network structure. It is, therefore, important to focus not only on aspects that will forge co-operation from within the organisation but from without as well (Alter, 1993).

b) Networks, clusters and industrial districts

Networks are characterised as developing in response to common problems shared by other businesses; working together to formulate network strategies and initiatives using a bottom-up approach; and on-going interactive relationships that do not cease after one event. A network is described as "a group of businesses that cooperate with each other in order to compete more effectively or to achieve together what each firm could not achieve alone" (Lichtenstein and Hoeveler, 1996)

One can distinguish between hard and soft networks. The difference between hard and soft networks is based on their difference in structure and formalisation. Within *hard* networks participants agree on a predetermined set of goals often set out in legally-binding contracts. Examples of such collaborative programmes are: apprenticeship training programmes; pooling resources and sharing projects to the extent of joint purchasing; dividing production processes amongst the participants and sharing learning programmes such as Total Quality Management. The degree of interdependence among members is high (Lichtenstein and Hoeveler, 1996; Kuper, 1997).

Soft networks are characterised by more fluid and informal relationships. Here the key factor is the strength that can be gained from affiliation and participation rather than obligation and responsibility. Examples of such collaborative programmes are: technology transfer networks by way of access to databases and technical assistance; resource sharing; networks with educational institutions offering customised or subsidised workforce training; and business development networks where participants seek out work from network members during slow periods or sub-contract work to network members during busy periods. Networks harden or soften along a trajectory becoming harder as the levels of shared commitment, risk and profit increase and softer as the reverse occurs (Lichtenstein and Hoeveler, 1996; Kuper, 1997)

Industrial districts are studied as forms of closely knit and very co-operative networks. An industrial district is a regional agglomeration of firms where firms form networks on a regional scale The literature on industrial districts, for example, compares the dynamics of co-operation to a community. A community is characterised by four aspects: common values and beliefs; direct relations as opposed to relations being mediated by the state; many-sided relations rather than specialised; and reciprocity. The degree to which these characteristics are present influences the degree to which a group constitutes a community. Therefore, the stronger the presence of these characteristics, the stronger the relations among the members of the industrial district, and the more successful their efforts. This is because communication is open, direct, it presents issues from all angles and promotes a sense of mutuality. Lorenz (1992) notes that there are ultimately two explanations for co-operation in communities, namely self-interest and "because it's the right thing to do". A third could be added, namely pressure from the government.

Clusters generally fit the category of soft networks. A number of firms that group together on a smaller scale than an industrial district into a production system are called a cluster. A cluster comprises suppliers, customers and other firms that produce similar goods (Bosworth and Rosenfeld, 1996).

c) Benefits of Networks

There are basically three types of benefits that can be achieved through networking. *Material benefits* bring cost savings, higher productivity, improved product quality and increased sales. *Psychological benefits* eliminate the sense of isolation, creating an opportunity for group interaction. *Developmental benefits* bring an increase in knowledge of one's field and training and learning opportunities that will shape the industry (Lichtenstein and Hoeveler, 1996).

d) Factors to consider before starting network programmes

The main factors that influence the success of network co-operations were listed by Lichtenstein and Hoeveler (1996):

- Inter-firm collaboration must be based on trust and co-operation among participants in the same way as it would between regular business partners. The success of the Industrial Symbiosis developed in Kalundborg is said to be based on the fact that all the decision makers working in the companies knew each other and have developed a relationship characterised by openness, communication and mutual trust.
- Networking must be industry-driven and linked to the specific needs of the participants
- Networks must be sustainable. That is, they must deliver measurable benefits that justify investment in time and money.

The basic purpose of any network is to develop activities that result in some form of co-operation, be it a hard or soft network on large or small scale.

In the following we shall only deal with co-operation mechanisms that are initiated for reasons of improvement of eco-efficiency. First we shall describe some of the different mechanisms that are used internationally, and then we shall analyse what would be needed to implement these mechanisms in the South African situation.

7.6.2 Industrial symbiosis mechanisms

A number of different co-operation mechanisms have been developed in different parts of the world, all with the common goal of improvement of eco-efficiency. The following presents a review of literature, and where appropriate, an evaluation of application or applicability of these “Industrial Symbiosis mechanisms” in South Africa.

a) Shared Savings

Manufacturing companies with a product focus strive to maximise sales of goods to their clients. This has a negative impact on sustainability because the use of natural resources is maximised as well. In order to move into a more sustainable direction, a transition to sales of service rather than of goods has been proposed. The concept of “shared savings” fits into this mould. This concept is based on a business model in which both supplier and customer have financial incentives to minimise resource consumption and waste (ENDS, 1997).

The concept of share savings is not a new concept. It has been applied successfully, in particular in the field of energy management. The energy supplier can win a share of the value of the energy savings it achieves for the energy consumer. This thus entails a shift from a business relationship based on the providing a product to a relationship based on providing a complete service package.

This is different from energy management practices in South Africa, where Eskom has set up an energy management consultancy company (Industrelek) to assist companies in saving energy. This company receives a fixed rate for their advice and not a share of the savings. Besides this initiative, there are companies (e.g. Professional Energy Services) who audit electricity bills for SMEs, also for a fixed rate and not a share of the savings (Fabricius, 1999; Sanderson-Smith, 1999).

According to Bierma and Waterstraat (1999), the shared savings concept also proved to be effective in chemical supply relationships. Chemical suppliers can improve their competitiveness by helping their customers to save money on chemical costs, improve their production efficiency and increase their product quality. The chemical supplier’s revenue is linked to chemical performance, rather than chemical supply.

The shared savings concept was discussed during the Second Industrial Symbiosis Workshop (Kothuis, 1999). It was concluded that in order to apply this concept successfully in South Africa, the price-volume conflict must be resolved and there must be a win-win situation for all involved parties. SMEs could outsource the business activities for which no financial, technical or human resource capacity is available or which is not a core business of the company; for example chemical and energy management and waste handling.

The barriers of the implementation of the shared savings concepts in South Africa were also addressed during the parallel session at the 2nd Industrial Symbiosis Workshop. The main barrier was perceived to be that SMEs often have no idea what the real costs are of their production stages. Besides that, all success stories of shared savings are achieved by large companies. Local success stories with SMEs are needed to encourage SMEs to get on-board. Another suggested barrier was that SMEs often apply crisis management which leaves no time to engage with the shared savings concept in order to make it work. A last barrier was that there might be a fear that control is lost over the business activities if company engages in a shared savings initiative around certain production steps or activities.

After the Second Industrial Symbiosis Workshop, a national chemical supplier has assessed the principle of shared savings, and discussed a shared savings contract between the chemical supplier and a Durban based metal finishing company.

b) Corporate Synergy Systems

Corporate Synergy Systems was introduced by Chiu et. al. (1999) as a management mechanism through which a number of manufacturing companies can strive towards shared management and production goals by working together. This would usually entail firms operating in the same supply chains, and where a logical relationship exists.

According to Chiu et al. (1999) and Groundwork Trust (1998) the concept of corporate synergy systems can promote cleaner production. Since SMEs have limited financial, technical capacity and human resources to improve their environmental performance on their own. Large, especially international, companies generally are stronger committed to good environmental practice as they have better access to financial, technical and human resources. These large companies could act as “environmental leaders” and help small and medium sized suppliers (up-stream) and buyers (down-stream) to improve their environmental performance. This assistance could entail technical and financial assistance, but also advice and training.

At the Second Industrial Symbiosis workshop, the concept of corporate synergy systems and its applicability in South African industry was discussed during a parallel session. There was a general consensus that South African companies are lagging behind in terms of devising and implementing corporate synergy systems. However, it is important in the long term for business sustainability (Kothuis, 1999). According to the participants of the parallel session, the most important issues related to the application of corporate synergy systems in South Africa were identified as:

- A company can only force or help other companies, up and down the supply chain, to improve their environmental performance if the “champion” company controls the environmental aspects of its own production process and product.
- The absence of a culture of talking to each other, and where it exists, it usually relates only to price and quality considerations.
- The greatest driver for corporate synergy systems are potential cost savings.
- The ‘Duty of care’ principle still needs to gather momentum and wider implementation to be successful and effective.

c) Shared Waste Treatment

Where treatment of wastes requires rare know-how or costly investments, it may be feasible for several companies to share a central waste treatment facility, or profitable for a separate company to offer such a service. Jänisch (2000, citing the US EPA, 1996b, and Barnett, 1999) discusses this as follows:

In the USA there are a number of off-site metals recycling services (U.S. EPA, 1996b). These were previously limited to spent solvents, precious metal wastes, and high purity common metal wastes, but now include services for a wider range of wastewater treatment sludges, and some facilities also accept spent chemical solutions. Companies that recycle metal accept limited types of waste, depending on their permit (issued by the

U.S. EPA). Centralised waste treatment (CWT) facilities which accept metal finishing wastes are becoming more common in other countries.

A successful Centralised Waste Treatment (CWT) initiative in South Africa has been the implementation of a facility for the off-site recovery of hydrochloric acid used in the hot dip galvanising industry. Once the iron level in the acid solution reaches above 10% it has to be discarded regardless of acid concentration. Since 1975, the acid (which previously was discarded in the sewers) is collected by a commercial company which regenerates it and sells it back to the galvanising companies. This project was initiated by the chairman of the Hot Dip Galvanising Association of South Africa. The Gauteng based organisation, collects the spent acid from all provinces, tankers it away, regenerates it and resells it to the users at the equivalent price as new acid. This has proven to be highly cost-effective and has been successful not only for galvanisers but also for other users of hydrochloric acid, e.g. companies which pickle steel to remove scale for a variety of reasons other than galvanising (Barnett, 1999).

The possibility of a centralised facility in the Western Cape Region of South Africa to recover chromium from electroplating sludges was briefly investigated during this project, and some useful descriptions of facilities operating in other countries were found (Mutsago and Gumbanjera, 1999).

d) Waste Minimisation Clubs

The concept of Waste Minimisation Clubs (WMCs) is to exchange experiences related to the implementation of the waste minimisation procedure among its company members. It has been proved that WMCs can encourage companies to improve their economic performance by reducing costs related to production of wastes (Barclay, 2000).

According to Huisingh & Mebratu (1998) WMCs can be classified in the local level of networking and are designed to promote co-operation among industrial leaders (market leading, progressive business) and to stimulate implementation of waste minimisation within and among their companies.

Approaches of WMCs should be based upon a process of training and involvement of several people from its member companies. Each company is conducting the waste minimisation assessment. By regular written and oral reporting within the WMC and support by external consultants, the potential to gain better results during the waste minimisation procedure is improved

Major steps for introducing WMCs are:
- identification of local resource person(s);
- introduction of waste minimisation concepts and solicitation of participants;
- training of key corporate and governmental participants;
- establishment and support of waste minimisation.

At the moment the concept of WMCs has been introduced in several countries, such as the United Kingdom, New Zealand, India and South Africa.

The first WMC in South Africa is the Metal Finishing WMC in the Durban region. This club was established by the Pollution Research Group of the University of Natal and funded by the Water Research Commission (WRC) at the end of 1997. Thirty metal finishing companies, with 5 to 200 employees, participate in this WMC. The main drivers for the companies to participate are the pressure of the local legislation and achieving costs savings by minimising wastes and emissions. The participants are all conducting a waste minimisation assessment. During official club meetings that are held every 3 months, the companies discuss the progress and results of their assessments. In this way companies can learn from each others ideas and mistakes. Workshops, seminars, presentations or company visits are organised between the official meetings. The topics of these events are chosen based on the interest of its members.

The Pollution Research Group has started a new WMC for the Hammarsdale region, also in the Durban area. Its members will include mostly medium sized enterprises. The members of this new WMC discharge their effluent water to the same sewage works. The driver of this WMC is to improve the quality of the discharges to the common sewage works, so the reduction of the water consumption and pollution shall have a very high priority during the waste minimisation assessment at the companies. At present 10 companies participate in this new club; among them are a textile and chemical company, a chicken abattoir and the sewage works. Both WMCs in the province Kwazulu-Natal are funded by the Water Research Commission (WRC).

The concept of waste minimisation clubs was discussed during the Second Industrial Symbiosis workshop (Kothuis, 1999). It was concluded that WMCs are a good starting point to promote waste minimisation or other industrial ecology concepts as it is a very simple concept, especially for SMEs. WMCs can also create strategic alliances where companies get together to solve a common problem. The general opinion of the participants of the parallel session, in which WMC concept was discussed, was that there is a need for a facilitator for initiating and leading a WMC.

As a direct spin-off of the project, two waste minimisation clubs are being established in Cape Town at the time of writing.

At the Second Industrial Symbiosis workshop, the drivers for WMC in South Africa were identified as regulatory pressure and enforcement of regulations, lack of other support alternatives, a champion as member of the WMC, and increased cost of waste disposal and resources (Kothuis, 1999).

e) Eco-Industrial Parks

An eco-industrial park is a community of manufacturing and service businesses seeking enhanced environmental and economic performance through collaboration in managing environmental and resource issues including energy, water, and materials. By working together, the business community seeks a collective benefit that is greater than the sum of the individual benefits each company would realise if it optimised its performance individually. This following discussion follows that in Kothuis (1999).

According to the work of Côté et al [1994] an eco-industrial park can have the following objectives:

- Conservation of natural resources;
- Conservation of financial resources;
- Reduction production costs relative to the volume of products;
- Reduction of raw material costs;
- Reduction of treatment costs;
- Reduction of energy costs;
- Reduction of environmental liability and insurance costs;
- Improvements in operating efficiency;
- Potential income through the sale of waste materials;
- Improvements in quality control;
- Improvements in public image with customers;
- Improved health for ecosystems and populations using the area;
- The need to respond to increasingly stringent legislation and higher fines.

The principle of an eco-industrial park is to decrease pollution and generated waste, and also to increase business success. The above mentioned objectives are achieved when the companies within an eco-industrial park start to exchange waste, facilities and information with each other. Industrial co-operations within the park should be beneficial to all involved business partners.

Two types of eco-industrial parks can be distinguished, greenfield parks and brownfield parks. A greenfield industrial park is planned and developed for its purpose and the land use is grouped for the specific industries to be established within the park. Brownfield parks are established eco-industrial parks where the eco-industrial park principles were added afterwards.

South Africa has very little or no experience with greenfield parks. This is now taking off in the United States and Europe. The most famous example of an already established eco-industrial park can be found in Kalundborg (Denmark), where the “industrial symbiosis” relationships grew spontaneously. Kalundborg is an ancient harbour town of farms and fjords. What made Kalundborg so fertile for growing industrial symbiosis relationships is the city’s environmental awareness and an ability to work together. Industries are relatively non-competitive among themselves. And stricter environmental laws were forcing these industries to rethink how they must go about with their business.

Two examples of greenfield parks in South Africa are:

Capricorn – Muizenberg. This is privately owned land that is currently being developed as an industrial park. It is an area of 200 ha and at present 67 ha is being developed. It is a sensitive area and therefor environmental issues are of great concern.
Coega, which is an industrial park still under development of 17,000 ha in the Port Elisabeth area. An environmental management plan is developed for the Coega site and it is a potential eco-industrial park.

During the second industrial symbiosis workshop, the topic "Eco-industrial parks" was discussed in one of the parallel sessions. The conclusion of this parallel session was that the eco-industrial park concept seems to be useful for South Africa. Developing countries, like South Africa, do not put environmental issues at the top of their priority list. However, no business in any country can afford not to consider environmental issues when making other important decisions effecting the economic performance. It was also concluded that there is a need for facilitation and funding to make the eco-industrial park concept successful in South Africa. The main question that has to be addressed is: who can fulfil the role of facilitator in South Africa? Funding is of significant importance because the establishment of an eco-industrial park is a costly and long-term project (Kothuis, 1999).

f) Waste Exchange Programs

Having its initial roots somewhere between recycling and re-use with attractive financial rewards for waste providers (in terms of waste disposal cost savings, reselling of waste materials) as well as waste users (replacement of expensive virgin material), IWE is practised very successfully around the world. The objective of a waste exchange program is to match the waste generators with waste users. The waste exchange concept is a powerful tool to turn wastes into valuable product again with a significant number of benefits for all involved parties (Dittke, 2000a).

The advantages of a waste exchange program have been summarised as follows by Novella and Dittke (2000a):

- The volume of untreated or unwanted waste ending up on landfill site is reduced.
- Waste disposal costs of a businesses is reduced or eliminated, the trading of wastes can even generate income for the companies.
- The need for natural resources is reduced as businesses start to use others company's waste as input material for their production process instead of buying virgin raw materials.
- Participation in a waste exchange program encourages businesses to communicate with each other, which might lead to the establishing of new co-operative and innovative business opportunities.
- Public recognition is received.
- Illegal dumping is combated.
- An ideal tool for local governments to enforce the principles of intergrated waste management.
- Industrial Waste Exchange can provide an integral part of an integrated waste management plan of an Environmental Management System of an organisation.

Industrial waste exchange is an internally successful waste reduction concept. In the USA, success stories on waste exchange practices are abundantly available (Dittke, 2000b).

The local government of Cape Town, the Cape Metropolitan Council, has recently created a waste exchange platform (Dittke, 2000a). An internet website was set up to provide this platform. Pressure on landfill sites in the Cape Town region has recently increased dramatically with the closure of a number of sites. The available land to establish new landfill sites in this region is limited. By facilitating this project, the local government aims to reduce the volume of all types of wastes ending-up on landfill sites.

g) Summary

Table 7-8 gives an overview of the industrial symbiosis mechanisms. It should be noted that Industry Associations are often offering information services on Environmental Management, and are well placed to advise member companies on the usefulness and applicability of various options. They thus have a support role to play in information brokering.

Table 7-8: The "Industrial Symbiosis" mechanisms

Symbiosis mechanism	Nature of link	Number of partners	Main partners of SME
Shared savings	Vertical	2	Supplier
Corporate Synergy Systems	Vertical	More than 2	Corporate client
Shared Waste Treatment	Horizontal	More than 2	Colleagues
Industry associations	Horizontal	More than 2	Colleagues
Waste Minimisation clubs	Horizontal or Random	More than 2	Consultant, Colleagues, Neighbour companies
Eco-Industrial Parks	Random	More than 2	Government, Neighbour companies, Service providers
Waste Exchange Platforms	Random	More than 2	Colleagues,

7.7 Opportunities for Co-operative Approaches?

A major finding of the Industrial Symbiosis project, already presented in chapter 4, is that numerous of the opportunities that exist in SME manufacturing to improve environmental and economic performance seem to be dependent on interaction of the manufacturing enterprise with outside organisations. The major achievements of the work presented in the paragraphs are, in our opinion:

- A systematic method has been developed to gather information on and to depict graphically the network around an SME manufacturing enterprise.
- It has been demonstrated how such company-specific networks can be interpreted to yield more general sector networks.
- This method has been applied to the selected case studies in the South African textile and metal finishing industries, from which valuable insights on flows, not only of material and finances, but also on information, could be gleaned.
- It has been shown how frequently encountered improvement methods in these sectors fit into these network maps, and which partners an SME should be looking to in order to implement such opportunities.

Further findings arising from the work presented in this chapter are that:

- the majority of the improvement opportunities encountered can be identified by the classical Waste Minimisation Assessment;
- an extension to this procedure may nevertheless yield opportunities otherwise overlooked;
- most of the SME manufacturing enterprises studied occupy a part of the production system where their major potential partner for the implementation of improvement options are suppliers of process chemicals, technology and know-how, with whom companies generally enjoy frequent exchanges of information.

We are thus of the opinion that the question whether there are opportunities for co-operative approaches can be answered in the affirmative. We base this answer both on the observed structure and characteristics of the studied manufacturing networks, and on the international experience with diverse co-operative mechanisms. The opportunities, in our opinion are there for the taking by (i) the suppliers of chemicals and know-how, and (ii) consultants who understand how to pool available resources to offer a cost-effective service. If applied judiciously, the "industrial symbiosis mechanisms" discussed in this chapter should yield benefits to both of these parties, and of course to the manufacturing enterprises. In general, we expect that in this way, larger production systems will also be driven closer towards a more eco-efficient state.

8 CONCLUSIONS

This last chapter of the final report presents a summary and brief discussion of the main results of the Industrial Symbiosis project. This is followed by our recommendations for policy development and for future research.

8.1 Main Results of the Industrial Symbiosis Project

In our view, the first important achievement of the Industrial Symbiosis project is the completion of first order waste minimisation assessments in the 10 selected case study companies. The results obtained and documented here substantially enlarge the knowledge base describing environmental performance of the smaller and medium-sized enterprises of the South African manufacturing sector. Whilst this environmental performance of the individual companies varied greatly relative to internationally accepted benchmarks, an important observation made was that improvement opportunities could be identified (and realised) even in those companies comparing well relative to the international benchmarks. This across-the-board existence of improvement potentials verified a basic premise of the entire research project, viz. that there is a need for better environmental management in the SME sector of the South African economy, at least in the textile and metal finishing sectors.

A second important finding of the project work is that the majority of the improvement opportunities identified in the case study companies would need, or would benefit from co-operation between the target company and what we describe as its “network partners”. In the majority of cases, such co-operation would be of an essential nature, which means that without co-operation with one or more outside organisations, the improvement option would not be implementable. The partners that were most often identified in this regard are the suppliers of technology and raw materials, and, to a lesser extent, the clients. This finding implies that supply chain management concepts might be interesting for many companies when considering different environmental management tools.

Another important class amongst the identified improvement opportunities is that consisting of options requiring improved housekeeping. These options were often found not to necessitate co-operation or support from an outside organisation, and should thus be evaluated separately from the Industrial Symbiosis context on which we focussed in our research. The wide-spread existence of this type of improvement potential suggests that SME manufacturing is often characterised by inadequate “process” control.

The third important achievement of the project pertains to documenting the relation between a target company and its “network partners”, and to utilising the gathered information to inform the planning of symbiotic relationships. Specifically, we have in this regard:

- developed a method to effectively gather the relevant information;
- developed network maps to depict this information both in a company-specific and a sector-generic network way;
- documented the relations between each of the 10 case study companies and its network partners in such maps;
- developed a formalised procedure to search within the company networks for opportunities to improve environmental performance of the target company; this procedure, which we term “Industrial Network Analysis”, can be used as an extension to the first order Waste Minimisation Opportunity Assessment;
- used this Industrial Network Analysis on two of the case study companies to identify further improvement opportunities.

At this stage of our conclusions we should, however, note that our research work has stopped short of utilising our understanding of the company networks in order to plan and establish a pilot symbiosis project around an identified improvement opportunity. We have however, been able to draw a number of conclusions regarding the generic company networks in the two industry sectors studied. The most striking amongst these is that the contact between textile companies and waste haulers or treatment organisations is much lower than for their counterparts in the metal finishing industry. This should, however, not be interpreted to mean that environmental impacts of the one sector are more severe than for the other, but should be seen to give information on solid waste generation only.

A number of additional important results of the project spring forth from our attempts to identify and describe factors that determine the ability of the case study companies to improve their environmental performance. (By implication, we are extrapolating these results to the SME sector of South African manufacturing in general.) In broad terms, we studied the fields of "management" and "economic health". Whilst both are relevant to our project-specific analysis of Industrial Symbiosis as a vehicle to improve environmental performance, our findings in these respects extend beyond this narrow focus, and describe the existing capacity to improve environmental management in the case study companies in general. Our main findings are:

(a) Management: We described the ability of management to improve environmental performance, be it by means of symbiosis concepts or other tools, in terms of company values, management intent and company capacity. Data was gathered and interpreted for eight of the ten case study companies. The results indicate that only two of the companies were well suited to participate optimally in industrial symbiosis networks. Both are in the metal finishing sector and one is not an SME according to the definitions discussed in Appendix 1. On the other hand, none of the other six companies studied in this respect was deemed to have a management profile disqualifying it per se from improving environmental performance, be it by industrial symbiosis or other means. However, for symbiotic functioning to become a feature in the industry, attention needs to be devoted to (i) nurturing of a company sense of responsibility towards the environment, (ii) diffusion of cleaner production know-how; (iii) development of human resources capacity and (iv) the building of capacity for innovative adaptation of production processes.

(b) Economic Health: This was evaluated with a specific view of assessing each company's ability to raise capital for continued sustainability of operations and further investment in (and maintenance of) technology and equipment. Data in six categories was gathered for nine of the ten case study companies. The results indicate that this factor represents a barrier towards improved environmental performance only for two of the smaller metal finishing case study companies. The other seven companies were deemed to be in a sufficiently strong position to devote resources to environmental issues. Interestingly though, when contrasting the economic health indicator to the dominant type of improvement opportunity identified, it was found that a positive correlation exists between poor economic health and the fraction of "good housekeeping" opportunities. Since improvements in housekeeping generally do not require capital investments, it may be concluded that even the companies in poor economic health are not disqualified from improving environmental performance to some extent. On the other hand, for companies in good economic health, the technology change type improvement opportunities, which require access to capital, were found to be significant. The fact that they had not been followed up on, despite given access to capital, indicates that other factors, such as access to the new technology and to skilled labour could be significant barriers towards improved performance.

As a further important achievement of the Industrial Symbiosis project, we should mention the work carried out with the objective of characterising the dynamics and characteristics of the two selected industry sectors, which provides the context in which the environmental performance of SMEs in the South African manufacturing sector is to be analysed. These contexts were summarised in chapters 2 and 3 of this final report.

Finally, amongst the important conclusions of our work is the finding that there is a need and opportunity for co-operative approaches to improving environmental management. A number of different approaches exist, and each situation will require judicious selection of the most appropriate one. Since this requires some specialist knowledge, we see opportunities arising more for well-resourced raw material suppliers who see themselves more as service providers than as chemicals manufacturers, as well as for environmental consultancies that understand how to pool the scarce resources of SMEs.

8.2 Recommendations for Policy Formulation

Based on the work carried out during the course of the Industrial Symbiosis project and presented in this final report, we recommend that the points listed below be considered for incorporation into policy development at a national (and regional) level. We realise that not all of these relate directly to the stimulation of symbiotic relationships but, as stated before, we view Industrial Symbiosis just as one amongst numerous vehicles to effect better environmental management amongst SMEs in the South African manufacturing sector.

1. Based on our observation that so many of the identified opportunities to improve environmental performance stipulate that the small or medium-sized enterprise in question would need support from a supplier of equipment or process chemicals in order to realise the identified gains, we recommend that

attention be paid to the development of mechanisms to stimulate such supply houses to lend more support to their clients. This could be effected in a number of ways: we propose either a voluntary industry agreement, or a more restrictive directive, aimed at limiting the sale of certain chemicals without proper support to the client (particularly in the fields of conversion efficiency and waste management).

2. From our findings that the largest single category of identified opportunities to improve environmental performance is that of good housekeeping, and that particularly smaller companies with poor longer term outlooks have a larger fraction of such opportunities, we conclude that more needs to be done both to improve sectoral economic performance, and to safeguard employee health and safety, and the environment. We recommend a mixed approach combining a more rigorous enforcement of the provisions of the Occupational Health and Safety Act with provision of information and advice on Cleaner Production techniques, possibly through DTI sponsored programmes or a DTI linked national Cleaner Production Centre.

3. Based on our analysis of management capacity in SMEs to improve sector environmental performance, we recommend that attention be paid to four focus areas: (i) nurturing of a company sense of responsibility towards the environment, (ii) diffusion of cleaner production know-how; (iii) development of human resources capacity and (iv) the building of capacity for innovative adaptation of production processes. Whilst the focus in all four should be broad enough to cover all aspects of preventative environmental strategy, specific attention to Industrial Symbiosis could be incorporated in a second phase of a project, subject to progress being made with the recommendations 4 and 5 below, and with the recommended future research.

4. Our analysis of economic health amongst SMEs in the textiles and metal finishing sectors leads us to believe that particularly for smaller companies, better access to capital is essential if environmental performance is to be improved. This can, however, not be expected to happen in a vacuum, and we recommend that it be coupled to guarantees to reduce risk, in part by improving environmental performance through contracting in of Cleaner Production skills, or through buying them in with technology or process chemicals, as per recommendation 1 above, or possibly in a symbiotic supply relation such as a shared savings concept. Further, without having carried out any research to support the following statement, we suggest that many small businesses may be experiencing difficulties in accessing scarce capital, and that a symbiotic relationship with empowerment venture capital, drawing in environmental management specialists as a third party, may lead to a renaissance in these sectors.

5. Finally, based on our analysis of company economic health and the observation that companies with an ability to source capital do not seem to invest sufficiently in cleaner technology, we recommend that mechanisms be developed whereby SMEs in a good financial position can be assured of better access to new technology and Cleaner Production skills. This could possibly be in the form of start-up assistance for a private Cleaner Production company, or through the establishment of a national Cleaner Production Centre, as per recommendation 2 above.

8.3 Recommendations for Future Research

Although all five of the conclusions in section 8.2 above pertain in some way or another to improving contact and co-operation between SMEs and some of their network partners, we realise that (with the exception of recommendation No. 4) they are not particularly specific to the concept of Industrial Symbiosis. This is the result of the nature of the Industrial Symbiosis project itself, which focussed on the context within which symbiotic relationships would have to be established, without being in a position to study a true symbiotic relation in South African industry.

We thus recommend that the knowledge gathered in this completed research project be put to use to plan and establish a pilot industrial symbiosis project around an identified improvement opportunity in one of the case-study companies, and to use this pilot study to gather experience for future policy development on the concept of Industrial Symbiosis. Ideally, such a pilot project should be conceived to involve three or more parties, possibly with the focus on provision of capital and know-how to a small enterprise. Possible partners to the small manufacturing company in such a pilot study could be the supplier of process chemicals, empowerment venture capital, and a consultancy specialising on preventative environmental strategy.

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